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THE QUARTERLY REVIEW
of BIOLOGY

INFLUENCE OF X-RAYS ON LIMB REGENERATION IN URODELE AMPHIBIANS

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INTRODUCTION

After Roentgen's discovery of x-rays, many papers were published dealing with their influence on the process of regeneration in different animals. Regeneration is a process of restoration of a missing organ or part. X-rays have proved to be a powerful and convenient method for experimental studies on regeneration as well as on other biological processes. It is possible that the general biological effect of x-rays on the living organism is based on the effect of x-rays on the mechanism of cell multiplication. Therefore, the investigation of the influence of x-rays on regeneration, in which a very intensive mitotic activity is observed, is particularly interesting. Such studies can give the investigator insight into the nature of the effect of x-rays, as well as knowledge of the nature of the regenerative process, and may enable him to solve certain problems, such as the source of cells for the regenerative blastema.

A knowledge of the nature of the effects of x-rays on the living organism is clearly important not only for experimental biology, but also for medicine. The therapeutic use of x-rays for different neoplastic growths needs a firm theoretical basis instead of a purely empirical one. X-ray biology must provide this theoretical foundation of x-ray therapy.

The most convenient vertebrates for studies on the effects of x-rays on regeneration are the amphibians, inasmuch as these animals possess the greatest ability among vertebrates to regenerate lost organs. Many papers have appeared in this field since the publication of the excellent review by Curtis (1936).

The purpose of the present review is to survey the basic problems in this field, as enumerated below:

I. The mode of action of x-rays in inhibiting regeneration.
II. The source of cells for the regenerating blastema.
III. The influence of x-rays on growth and differentiation in the regenerative process.

In this review some new papers, particularly those in Russian, which have seldom been referred to in the English literature of the subject, will be considered in relatively greater detail than better known publications.

THE NORMAL PROCESS OF REGENERATION

Among the *Amphibia*, the *Urodela* (newts, axolotls, salamanders, etc.) are able to restore limbs, tail, and even parts of the head following injury or amputation. For a short time after the amputation of one of these parts, bleeding is to be observed. However, due to contraction of muscles and constriction of blood vessels, the bleeding soon stops. Then the healing process begins. The initial epidermal healing of the wound is accomplished by a migration of epidermal cells or by migration of the epidermal layer from adjacent regions. This process occurs without extensive mitotic activity (Korschelt, 1927). The process of wound healing is a separate process which has nothing to do with regenerative ability. It occurs in animals which are able to regenerate missing parts as well as in those animals which are unable to do so. But in animals which possess the ability to regenerate, the latter can be manifested only after the completion of wound healing.

Commencement of the regeneration process depends not only upon the ability of the organ to regenerate, but also upon the presence of suitable conditions. Regeneration cannot begin, for example, in the absence of a freshly healed wound. If, immediately after the amputation of an organ, the wound is closed with adjacent old skin, regeneration does not occur (Godlewski, 1928, and others). It is possible that the skin may be responsible for the suppression of limb regeneration in animals which do not regenerate limbs naturally, such as adult frogs (Rose, 1944). Larval skin is able to promote limb regeneration in the frog (Gidge and Rose, 1944).

The process of regeneration in the Amphibia starts with degeneration (resorption) of the old cut tissues. The giant wandering cells phagocytize all distal portions of the tissues, all cut and damaged cells, dead blood cells, et cetera. Immediately thereafter, in the distal portion of the amputated organ, accumulated mesenchymal cells begin to divide rapidly. These form the rudiment of the new regeneration tissue—the regeneration blastema (Korschelt, 1927). After the formation of the regeneration blastema, a period of more rapid regeneration, with progressing tissue differentiation, is to be observed. By the end of 25 days after limb amputation, three digits appear on the regenerating limb of *Amblystoma punctatum* (Butler, 1933, 1935). Usually within two months after the amputation, the formation of a full-sized limb with 5 digits can be observed in adult tritons (*Triton cristatus*) and in adult axolotls (*Siredon mexicanum*) (Brunst, 1938). The regeneration is a very rapid morphogenetic process. The missing organ may be restored in one-fourth or one-fifth of the time required for normal ontogenetic development.

SOME GENERALIZATIONS CONCERNING THE SPECIFIC INFLUENCE OF X-RAYS ON THE LIVING ORGANISM

Usually the reaction of organisms to x-ray treatment is observed only after a more or less prolonged time. This interval between irradiation and the appearance of the reaction of the organism to the treatment is termed the latent period. Its duration is influenced by many factors. One of these is the rate of division of the irradiated cells (Packard, 1931). The division rates of spermatogonia are high, and they begin to degenerate two hours after irradiation. Lymphocytes, especially in their early developmental stages, are likewise very sensitive. A few hours after irradiation, an "explosive" disintegration of these cells can be observed (Heineke, 1914; Schrek, 1945). According to Spear (1946), "less than 10 r of x-radiation is required to affect the leucocytes of the blood, while a dose of 100,000 r has no demonstrated effect on the isolated frog's heart." Injuries of the skin in man become apparent only after several days (Packard, 1931). Another factor which influences the duration of the latent period is the intensity of the treatment. The greater the intensity, the sooner the reaction appears (Packard, 1931). But according to Schechtmann and Klüpfel (1932), the reaction following treatment of early developmental stages of frog's eggs with a small dose of 20 r units, as well as treatment with a large dose of 72,000 r units, becomes visible after a latent period of at least 24 hours. However, according to Glocker and Langendorff (1933), when a massive dose is administered to the same material in a very short time (for example, 600,000 r in 10 minutes), the latent period is absent, and the reaction takes place immediately in all treated eggs which do not continue cleavage.

Some authors have attempted to explain the presence and variability of the latent period. For example, according to Schwarz (1926), x-rays provoke in treated cells the formation of new chemical substances, actinoproteins, which have weak toxic activity. Gradually these substances transform themselves into more active actinoproteins with greater toxicity. At that time when the quantity of such toxic substances is sufficient to produce some visible changes, the latent period ends, and the reaction of the treated tissues begins. The greater the amount of treatment, the more intense are these changes, and the shorter the latent period. Similar latent periods are observed in reactions of the organism to injections of tuberculin or mustard-oil (Schwarz, 1926). A latent period is observed also after irradiation of amphibian regenerates (Butler, 1933; Brunst and Scheremetieva, 1933; Puckett, 1936; Brunst, 1938). The duration of the latent period in the adult *Triton cristatus* varies from 15 to 30 days (Brunst, 1938).

At the end of the latent period, relatively acute and profound changes in the treated tissues can be observed. These alterations of the cells often cause a suppression of mitotic divisions and signs of pathological degeneration, such as the formation of degenerated giant nuclei or pycnotic nuclei in many cells (visible injuries). All cells with high sensitivity to x-rays die. At this point, in many cases, the reaction of irradiated tissues is similar to an inflammation. This reaction can be termed the "primary acute" reaction (Brunst, 1944). In many cases the injuries to cells can be observed soon after irradiation (Alberti and Politzer, 1924; Canti and Donaldson, 1926; Cox, 1931; Fuchs and Politzer, 1932; Marquardt, 1938; Doljanski and Goldhaber, 1943; and others). After small doses, just sufficient to give the primary reaction, it appears in a mild form only. Thus, irradiation of tissue cultures produces at first a suppression of mitoses, then a stimulation, and finally a return to the normal condition (Canti and Spear, 1928, 1929). A temporary reduction of the division rates in *Paramecium* (Packard, 1931) and a temporary stimulation in eggs of *Planorbis* (Richard, 1914) and *Arbacia* (Packard, 1916) have been observed. If the irradiation is strong enough, the normal mitotic rates are never restored in treated tissue cultures (Canti and Spear, 1929). As stated above, the process of inflammation is a very typical, primary, acute reaction of treated tissues to x-ray injury. The erythema of human skin is a well known example of this. In consequence of the inflammatory process, many of the treated cells and even parts of tissues may disappear. However, in some cases the primary reaction is not observed, in spite of the fact that serious alterations in the treated organ may be detected considerably later. For example, in treated adult limbs of *Triton cristatus* no sign of a primary reaction appears (Brunst, 1944).

Some time after the primary reaction, a stable state in the irradiated organs can be observed to last for an unlimited time. The inflammation and all other phenomena characteristic of the primary reaction disappear before the advent of this stable state. It may arise regardless of whether the primary reaction has been acute, mild, or non-existent. The surviving tissues recover their normal appearance but not certain of their vital potentialities. The cells appear to have lost the capacity to multiply. Since it has not been possible to see such changes with the usual microscopic techniques, they have been designated "invisible injuries." This reaction, or stable state, has been called the "secondary" reaction (Brunst, 1944).

The effect of x-ray irradiation upon the living organism depends not only upon the sensitivity of the tissues of the organism and upon the dose applied, but also upon the method of treatment. Different results may be obtained, for example, by using total or local irradiation, and many other conditions of radiation have also to be taken into consideration. The general effect of a total irradiation of the organism is frequently such a complicated reaction that the simple reactions of separate parts of the organism cannot be distinguished. Moreover, such a complicated generalized reaction often does not allow the treated organism to live on, so as to exhibit the reaction of the organ being studied. Even the size of the locally irradiated area influences the effects obtained. The greater the area treated, the greater the proportion of cells killed (Hercik and Klusakova, 1939).

THE INHIBITION OF REGENERATION BY X-RAYS

A. Total body and local irradiation

A dose of irradiation large enough to provoke a general effect upon the organism also influences the process of regeneration. Scheremetieva and Brunst (1933) have made parallel total body and local irradiation of tadpoles of *Pelobates fuscus* with regenerating tails. The regenerating organs were influenced more strongly by the total body irradiation than by the local, as they were influenced indirectly, through the irradiation of the body, as well as directly. Indirect influence of this sort is suggested by the work of Caspary (1926), who believed that injury and disintegration of cells results in the formation of substances, termed necrohormones, which are carried by the blood stream (cf. Calo, 1932; Barnes and Furth, 1943). Necrohormones evidently may be postulated to explain the reaction of parts of the body not directly exposed to massive treatments (Leblond and Segal, 1942). However, no influence of irradiated media on tissue cultures has been found by Osgood (1942) or others. Experiments have been made in which the entire bodies of axolotls (*Siredon mexicanum*), with the exception of regenerating limb buds which were carefully protected from irradiation, were given a lethal dose. The legs regenerated normally before the animals died (Litschko, 1934). When the posterior halves of the bodies of *Amblystoma punctatum* larvae were irradiated, normal regeneration was observed in amputated forelegs (Butler, 1934). In other experiments, untreated *Amblystoma* legs were transplanted onto a treated host, and after the transplant became established, a part of it was amputated. Regeneration took place normally (Butler, 1935). In all the latter cases, radiation of the body elsewhere failed to influence the local regeneration process.

The total treatment of individuals with a regenerating part has been made by several investigators (Schaper, 1904; Litschko, 1930, 1932, 1934; Butler, 1931, 1932, 1933; Scheremetieva and Brunst, 1933; Crummy, 1935; Puckett, 1936; Butler and Puckett, 1940). No clear picture, however, of the influence of total body irradiation on the regeneration process has emerged. It is particularly unfortunate that the amounts of treatment necessary for the suppression of the regeneration process are lethal to the organism, and therefore prevent long continued observations on this process. For this reason, many authors have applied local irradiation to regenerating body parts (Brunst and Scheremetieva, 1933, 1937a, b; Brunst and Chérémétieva, 1935a, b; Scheremetjewa and Brunst, 1933, 1935, 1937, 1938; Litschko, 1934; Butler, 1935; Umanski, 1937; Brunst, 1937a, 1938a, b, 1941, 1944; Butler and O'Brien, 1942). The localization of the treatments has been attained by various means. In some experiments the animal, except for the part to be treated, was protected by lead rubber (Litschko); in others, lead plates were used to protect the animal (Butler; Butler and O'Brien); yet again, the animal to be treated has been covered by a lead cover with a localizer tube (Brunst and Scheremetjewa; Scheremetjewa and Brunst).

When the leg of an adult *Triton cristatus* is given 10,000 r units of x-rays through a narrow localizing tube, regeneration is completely inhibited in about 95 per cent of the individuals. Administration of 4000 r produces, with a similar technique, a complete inhibition of regeneration in only 54 per cent of the animals, while in the remainder all possible degrees of disturbance may be observed. Extremely variable results are obtained after treatment with 1500 to 2500 r units; all degrees of retardation and inhibition of regeneration are to be observed (Brunst and Scheremetjewa, 1933; Brunst, 1938). Analogous erratic results caused by small doses of x-rays on embryonic developmental processes and on the growth of tumors have been found by Bardeen (1909), Holthusen (1921), and others. Complete uniformity of results, such as the complete supression of the regenerative process, is rather difficult to obtain, a treatment several times greater than that which suffices to induce the effect in 50 per cent of the individuals being needed. Some cells remain uninjured even after heavy irradiation (Crowther, 1924; Dessauer and Caspari, 1926; Dessauer, 1931; Packard, 1931). This is true for total body irradiation as well as for the irradiation of separate organs, eggs, or tissues. This is well illustrated by the results of irradiating *Ascaris* eggs (Holthusen, 1921) and *Drosophila* eggs (Packard, 1931).

A dose of 5000–6000 r units is large enough to suppress regeneration in the adult axolotl, *Siredon mexicanum* (Scheremetjewa and Brunst, 1935; Umansky, 1937). In *Eurycea bislineata*, a dose of 5000 r units inhibits regeneration (Butler and O'Brien, 1942). This does not mean, however, that such an amount of radiation is sufficient to suppress regeneration in any amphibian. The sensitivity to radiation varies not only in widely divergent species but even in closely related forms. For example, 500 r units is absolutely lethal for a guinea pig, while a lethal dose for a mouse is close to 1200 r units (Clark, 1934; Ellinger, 1945; see also Henshaw, 1944). This makes it difficult to derive generalizations from the results obtained with any one animal.

The problem arises as to how to interpret the inhibition of the capacity for regeneration. A priori, it may be considered either temporary or a permanent disappearance of the capacity. This problem can be settled only by observing the behavior of treated animals over long periods of time. One limb of each of several individuals of *Triton cristatus* was subjected to local treatment with variable amounts of x-rays (Brunst and Chérémétieva, 1936). During 5 to 6 years of observation, these limbs were amputated repeatedly, in some animals three, in others four, five, six, or seven times. In 13 cases the regenerative capacity was found to be completely destroyed, while regeneration of the untreated control limbs on the opposite sides of the same animals took place quite normally. These 13 animals had been irradiated with different doses of x-rays: 3 with 15,000 r; 8 with 3750 r; 2 with only 1500 r. Figure 1 shows the sizes of irradiated and control regenerating limbs during the period of observation. Similar observations were made upon axolotls, *Siredon mexicanum* (Brunst and Chérémétieva, 1936; Scheremetjewa and Brunst, 1937).

Attempts were made by means of traumatization to stimulate irradiated limbs of *Triton cristatus* to regenerate. The distal side of each irradiated stump was pricked and the wound surface scratched by a needle (see Tokin and Gorbunova, 1934). Such traumatization had no effect on regeneration after heavy irradiation (15,000 or 7,000 r). Regeneration did not take place (Brunst, 1938).

B. Effect on the regenerating limb of irradiation after amputation

The problem of the differential sensitivity to radiation of cells at different stages of the mitotic cycle has been considered extensively. Many authors hold that dividing cells are most susceptible. Some of these have regarded the prophase as the most sensitive stage (Packard, 1916; Strangeways and Hopwood, 1926; Henshaw, 1938, 1940; Henshaw and Cohen, 1940; Creighton, 1941; Carlson, 1942); some, the metaphase (Holthusen, 1921; Whiting, 1940; Bozeman, 1943); some, the anaphase (Creighton, 1941; Sparrow, 1944); and still others, the telophase (Vintemberger, 1928; Luther,

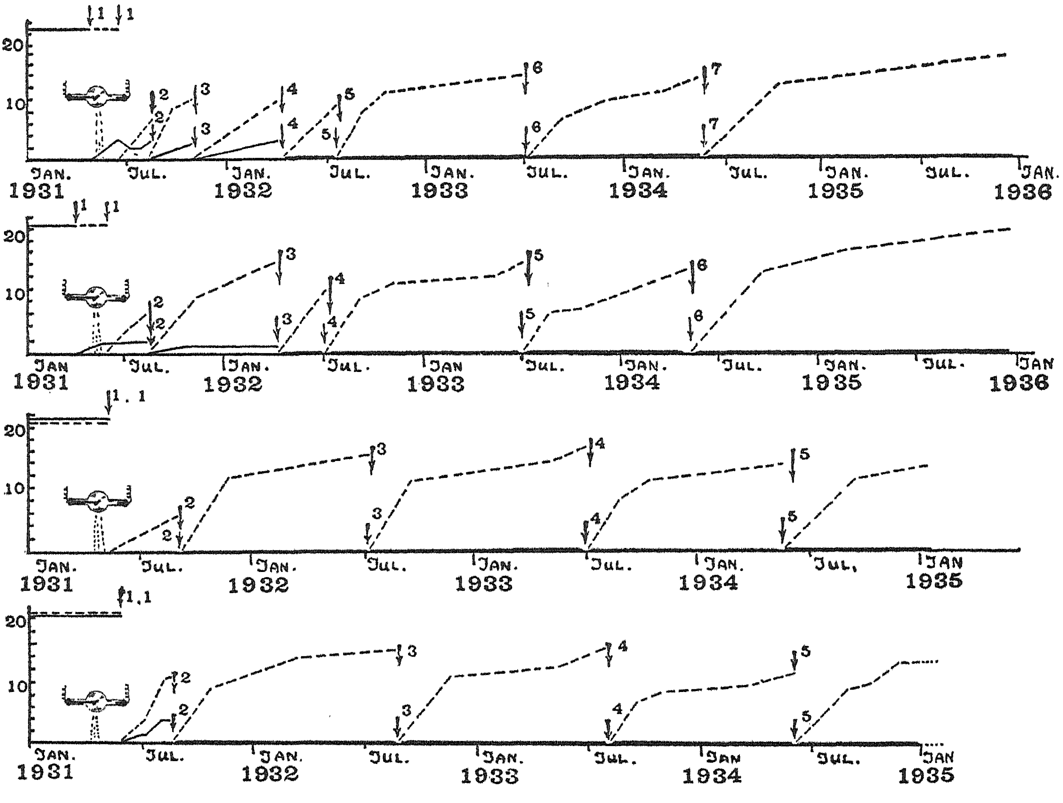

FIG. 1. INHIBITION BY X-RAYS OF THE GROWTH OF REGENERATING LIMBS IN TRITON CRISTATUS

Growth curves of limb regenerates during several years. Ordinates: sizes of limbs and regenerates in mm. Abscissas: periods of observation. The x-ray tubes symbolize the time of irradiation of the right limbs. The growth curves of the irradiated limbs are shown by continuous lines, those of the control (left) limbs by dotted lines. The arrows show the times of amputations. The number beside each arrow gives the ordinal number of the respective amputation. In all cases, irradiation with 3750 r. (After V. V. Brunst and E. A. Chérémétiéva, 1937).

1938). "Practically every stage of the cycle (mitotic) has been regarded as the most sensitive phase" (Giese, 1947, p. 267). Some investigators have not found the dividing cells particularly sensitive (Love, 1934). Possibly Politzer (1930) is nearest the truth in thinking that the fact that abnormal mitoses are observed after irradiation does not necessarily mean that the dividing cells are most sensitive. The resting cells also are injured, but their injuries are made manifest only after such cells have entered division (see also Butler, 1932).

This view was confirmed by studies involving a comparison of the influence of x-rays on regenerating and on adult amphibian limbs. Such studies were made with *Triton cristatus* (Brunst and Scheremetjewa, 1933) and with the axolotl, *Siredon mexicanum* (Scheremetjewa and Brunst, 1935). In these experiments the regenerates were, at the time of treatment, in the regenerating bud stage or in the stage of finger formation. In the group of adult animals used for comparison, the irradiation of the extremities preceded their amputation. Suppression of the capacity of an adult limb to regenerate proved to require no greater amount of treatment than is needed to suppress the growth of a regenerating extremity. Yet an adult limb has few or no dividing cells, while a regeneration bud contains many cells in different stages of mitosis. This does not mean, however, that the adult and the regenerating limbs react similarly to radiation. Indeed, irradiation of a regenerating limb causes not only an arrest of regeneration but usually a more or less rapid decrease in size, or reduction, of the treated regenerate, as well.

If 5,000 to 7,000 r are administered to two-months-old limb regenerates in axolotls, such a reduction is observed in nearly every animal (Brunst, 1938, 1941, 1944). Following irradiation, regeneration continues normally for 2 to 6 weeks, sometimes even up to several months. After this latent period, regeneration stops and reduction begins.

The reduction always begins in the distal end of the regenerate. Thus, if at the onset of reduction the bud has rudiments of toes, the distal ends of the toes are first to show reduction in size. One of the signs of the beginning of intensive reduction is a change in coloration of the regenerating limb. The toes and adjacent portions lose their pigmentation and become light and semi-translucent. This is caused by a change in the pigment layer (Brunst, 1941, 1944), a characteristic biological reaction which has been described by numerous authors (Levine, 1931; Smith, 1932; Scheremetjewa and Brunst, 1933; Ellinger, 1940; Davison and Ellinger, 1942). The pigmentation is usually destroyed; but occasionally, on the contrary, it is intensified, an effect explainable by the redistribution of pigment cells in the skin. The epidermis of the regenerating, and now reduced, limb remains intact, and no open wound is formed. If the process of reduction continues unabated, then, following the disappearance of the toes, it continues proximally until complete dissolution of the regenerate has taken place.

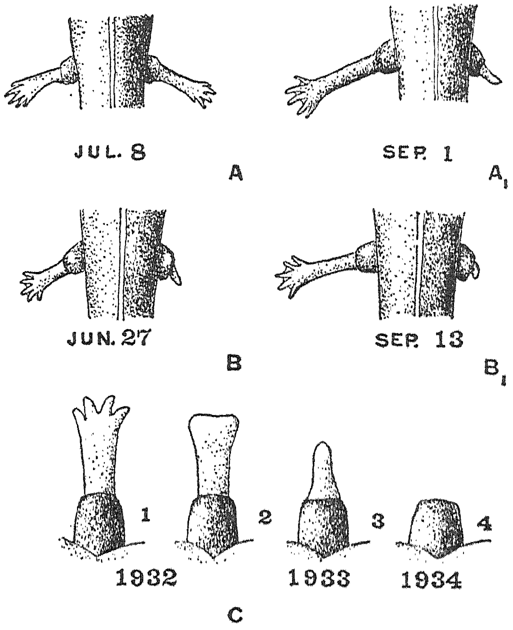

FIG. 2. THE REDUCTION IN SIZE OF X-RAYED AND THE GROWTH OF CONTROL REGENERATING LIMBS IN THE AXOLOTL, SIREDON MEXICANUM

(Semi-schematic drawing of actual specimens).

A. The region of the hind limbs, 60 days after amputation of both limbs and three days after local irradiation of the right regenerate with 6000 r.

A_1. The same region 54 days later.

B. The region of the hind limbs, 41 days after amputation of both limbs and 32 days after local irradiation of the right stump and small regenerate with 3750 r.

B_1. The same region 78 days later.

C. 1. The hind limb 41 days after local irradiation of its regenerate with 15,000 r; 2. The same extremity 18 days later; 3. The same extremity one year later; 4. The same extremity one year and 5 months later. (After V. V. Brunst, 1938).

The reduction process, however, varies in intensity. In some cases the regenerating limb becomes completely destroyed in a few months

(Fig. 2A, B). In other cases, a slow but steady reduction process goes on for several years (Fig. 2C). In the case illustrated the process continued for at least 2 years and 5 months, resulting in complete destruction of a well developed regeneration bud with rudiments of toes (Brunst, 1938, 1944).

Histological examination of the limbs undergoing reduction has shown that their structure differs widely from that of normally regenerating limbs, as well as from normal adult limbs. Limbs undergoing reduction contain large numbers of cells which are strikingly different from the normal tissue constituents, and are characterized by their large size, the smallest being two to three times as large as connective tissue cells. These "giant" cells of various shapes and sizes are shown semi-schematically in the figure (Fig. 3). Normal epithelial cells, connective tissue cells, erythrocytes, and a micrometer scale are given for comparison. The length of an erythrocyte is about 0.02 mm. and the normal epithelial cells about 0.02–0.03 mm. The connective tissue cells are even smaller. A majority of the giant cells are 0.04 to 0.06 mm. long (Fig. 3G). The largest ones measure up to 0.1–0.12 mm. in length (Fig. 3, A–F), equalling the entire thickness of the normal epithelial layer. The giant cells are amoeboid and devoid of any fixed shape. Each possesses a large granular nucleus and a nucleolus (Fig. 3C). The nucleus may be obscured by the presence of various inclusions in the cytoplasm (Fig. 3D, E). Mitotic divisions of the giant cells have been observed (Fig. 3H). Phagocytic activity of these giant cells has been established by direct histological observation (Fig. 3F). The reduction process is clearly connected with the presence of these giant cells and with their destructive activity. The portions of the limb in which this process is going on can be definitely identified by their presence. Parallel with the accumulation of the giant cells, the irradiated tissues and tissue complexes disappear in the limbs undergoing reduction.

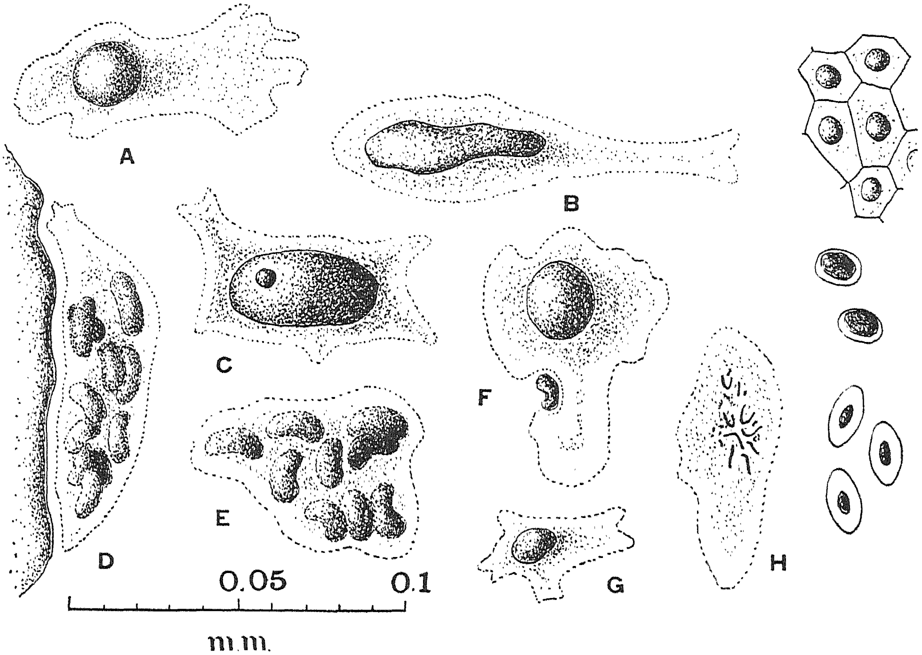

FIG. 3. CELLS OF NORMAL AND X-RAYED TISSUES IN THE AXOLOTL, SIREDON MEXICANUM

(Drawn at the same magnification with the aid of a camera lucida).

1–3: Normal cells of an untreated axolotl. 1, epithelial cells; 2, connective tissue cells; 3, erythrocytes. A–H: Giant cells of the regenerating limbs after treatment with various doses. (After V. V. Brunst, 1944).

The reduction of different tissues occurs as follows (Brunst, 1941, 1944). The continuous subepithelial pigment layer is absent in the semitransparent regenerating limbs undergoing reduction. Giant cells are found in the tissue underlying the disappearing pigment layer. Usually one can see scattered single pigment cells, and in some

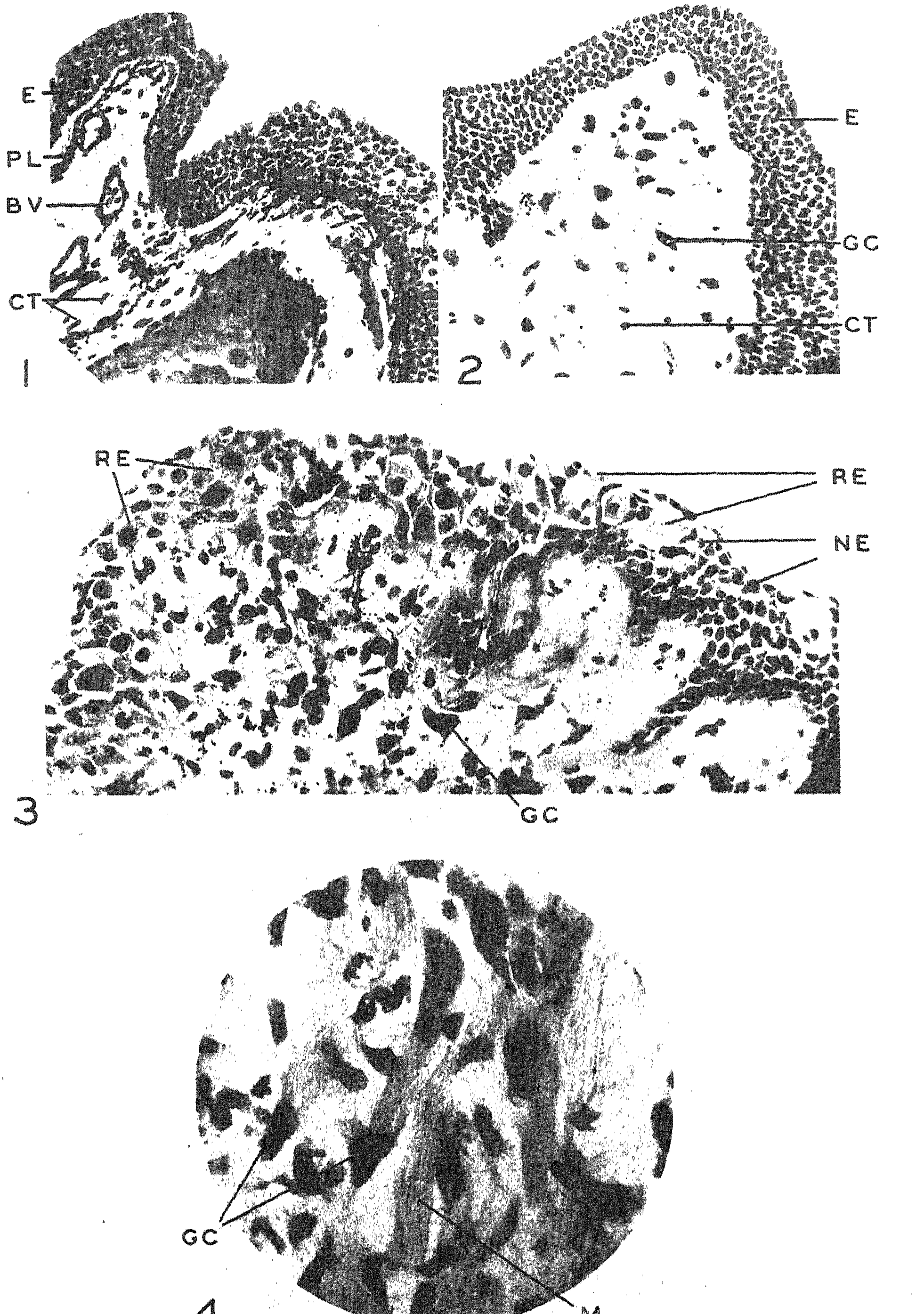

Fig. 4. Reduction of X-Rayed Regenerating Limbs in the Axolotl, Siredon mexicanum

1. Part of a section through a regenerating limb of a control animal, showing the normal subepithelial pigment layer. E, epithelium; PL, pigment layer; BV, blood vessel; CT, connective tissue cells. × 120.

2. Part of a section through a regenerating limb x-rayed with 6000 r and undergoing reduction. GC, giant cell; other symbols as above. Note that all pigment cells have disappeared. × 120.

3. Part of a section through a regenerating limb x-rayed with 7000 r. Reduction of the epithelium. RE, epithelium in process of reduction; NE, normal epithelium; GC, giant cell. × 200.

4. Part of a section through a regenerating limb x-rayed with 7000 r. Reduction of the muscles. GC, giant cells; M, muscle fiber. × 450. (After V.V. Brunst, 1938, 1944).

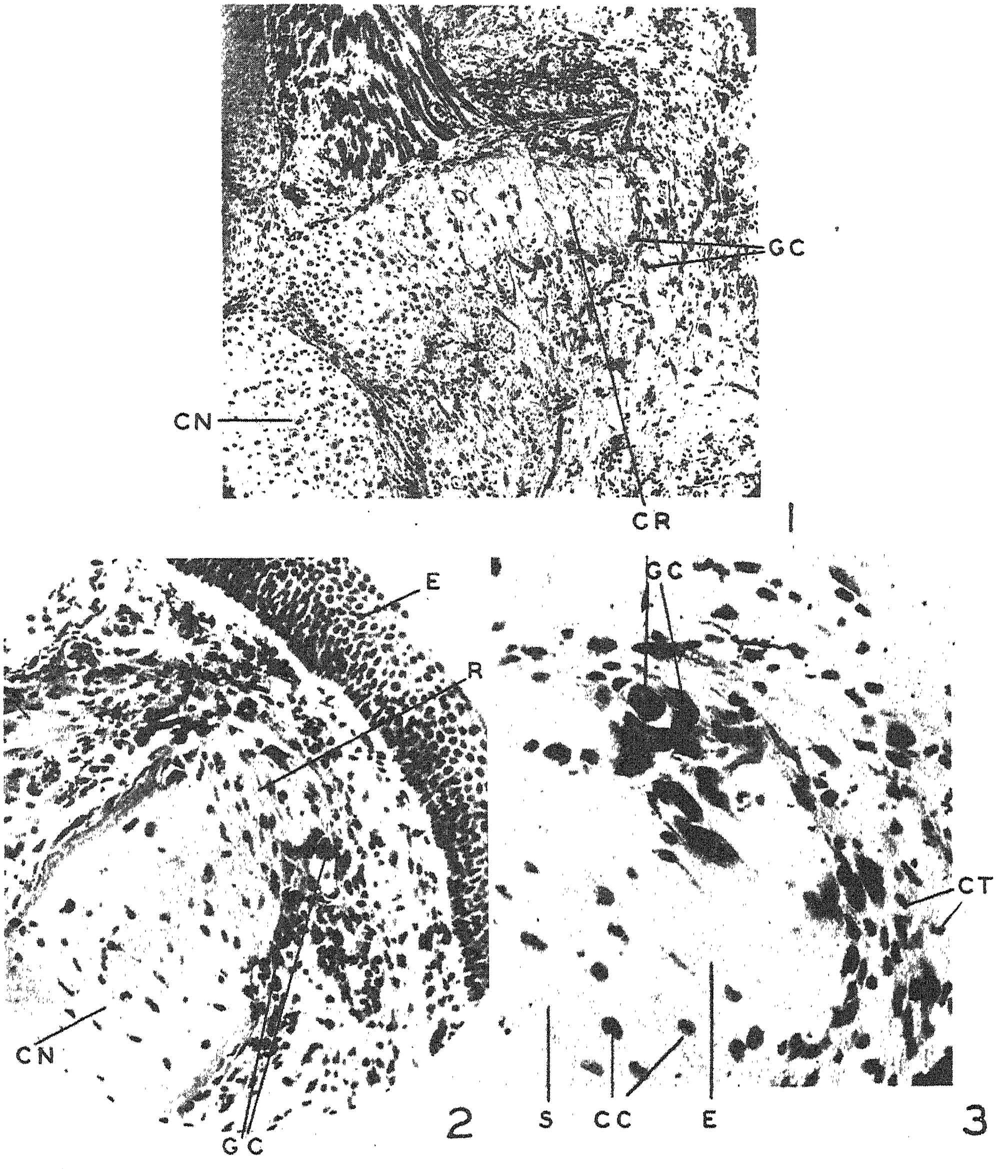

FIG. 5. REDUCTION OF X-RAYED REGENERATING LIMBS IN THE AXOLOTL, SIREDON MEXICANUM

1. Part of a section through a regenerating limb x-rayed with 7000 r, undergoing reduction. CN, normal cartilage; CR, cartilage in process of reduction; GC, giant cells. × 50.

2. Part of a section through a regenerating limb x-rayed with 6000 r. Reduction of the distal part of the toes. E, epithelium; CN, normal cartilage; R, cartilage in process of reduction; GC, giant cells. × 100.

3. Part of a section through a regenerating limb x-rayed with 7000 r, showing penetration of the giant cells into the cartilage, which is undergoing reduction. CC, cartilage cells; S, the cartilaginous intercellular substance; E, empty space previously occupied by a cartilage cell; GC, giant cell; CT, connective tissue cells. × 200. (After V.V. Brunst, 1944).

parts even such single cells are lacking (Fig. 4, 1 and 2). Characteristic changes in the epithelium of the toes undergoing reduction can be noted. On the distal ends of the toes it becomes reduced in thickness, sometimes down to two layers of cells, whereas the normal epithelium of a regenerating limb has from 7 to 10 cell layers. Spaces or cracks form between the enlarged epithelial cells, and large groups of giant cells appear in the subepithelial tissue, although only a few of them lie in immediate proximity to epithelial cells (Fig. 4, 3). This fact suggests that the epithelium is reduced because of lytic enzymes secreted by the giant cells. The epithelial covering gradually recedes and becomes reduced simultaneously with the disintegration of the subepithelial tissues in the region where phagocytosis is occurring. The giant cells concentrate around the muscles of the limbs undergoing reduction. It is probable that musculo-lytic enzymes are also secreted by the giant cells (Fig. 4, 4). The process of reduction of the cartilaginous skeleton is perfectly clear. The distal cartilaginous elements of the reducing limb look distinctly different from the proximal elements (Fig. 5, 1). The number of cartilage cells in the distal elements decreases rapidly; numerous empty cavities are evident in areas once occupied by the living cells. Large numbers of giant cells are massed around the skeletal elements undergoing reduction. At higher magnifications giant cells can be seen attached to the surface of the cartilage, and eventually penetrating the cartilaginous substance (Fig. 5, 2 and 3). Cartilage cells occasionally may be seen engulfed in the cytoplasm of the giant cells (Fig. 3D, E and Fig. 5, 3). Thus the process of reduction of the cartilaginous tissue is accomplished, at least in part, by phagocytosis. This is probably combined with a lysis of the cartilage substance by enzymes secreted by the giant cells. The degree of disintegration of the skeleton of the limbs in the process of reduction can be judged from the reconstructions shown in Figs. 6 and 7.

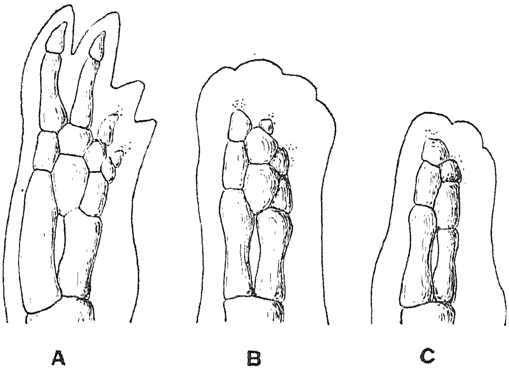

FIG. 6. REDUCTION OF REGENERATING LIMBS X-RAYED WITH 6000 R IN THE AXOLOTL SIREDON MEXICANUM

Reconstructions of skeletons. A, B, C, differing degrees of reduction in different individuals. Aggregations of giant cells are indicated by stippling. (After V. V. Brunst, 1944).

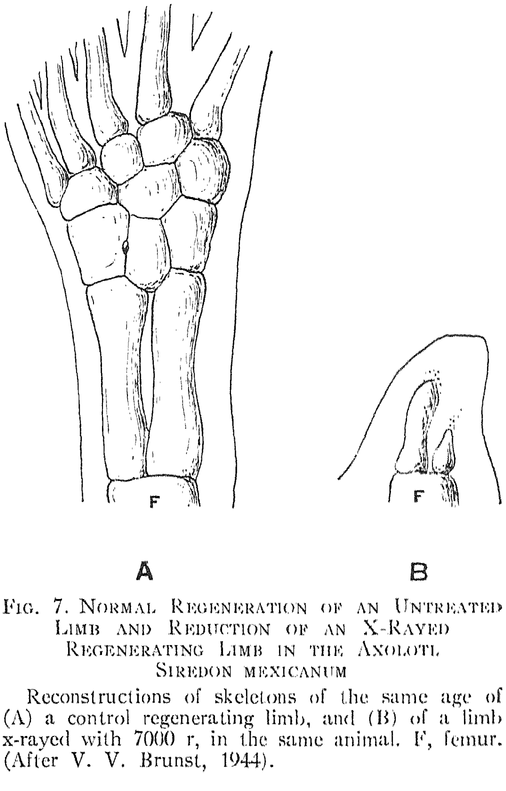

FIG. 7. NORMAL REGENERATION OF AN UNTREATED LIMB AND REDUCTION OF AN X-RAYED REGENERATING LIMB IN THE AXOLOTL SIREDON MEXICANUM

Reconstructions of skeletons of the same age of (A) a control regenerating limb, and (B) of a limb x-rayed with 7000 r, in the same animal. F, femur. (After V. V. Brunst, 1944).

It is instructive to compare the process of reduction observed in the irradiated regenerating limbs with resorption such as takes place in the normal development of certain amphibians, especially that which occurs at the time of metamorphosis of anuran tadpoles. Studies on the resorption of the tadpole's tail have shown that this process occurs by means of phagocytosis and histolysis (Batallion, 1891; Duesberg, 1906 1907; Aleshin, 1936; and others). It too begins distally and progresses proximally. Large aggregations of macrophages (giant cells) were found by Aleshin (1936) in the distal end of the tail of each metamorphosing tadpole. A majority of these macrophages are derived from the blood cells, and only a few are mesenchymal in origin. Resorption of the tadpole tail is a reaction not unlike that involved in inflammation. Indeed, the resorption of the tail begins and progresses like a typical inflammation, although the end result of the process is quite different, inflammation resulting in the appearance of a connective tissue scar, whereas resorption leads to complete disappearance of the tail (Aleshin, 1936). Since the resorption of the tadpole's tail and the reduction of the limbs in x-rayed axolotls are so similar, the latter process also resembles inflammation, even though the final results of reduction and of inflammation are again quite different (Brunst, 1941, 1944).

One might compare the giant cells observed in the reduction process in the axolotl with polyblasts or macrophages in the sense of Mechnikov (see Maximov, 1906a, 1906b, 1923, 1932). These actively wandering connective tissue cells, which generally appear at the sites of inflammatory processes, should be expected in the irradiated body parts, since such a process occurs here. These cells migrate toward inflamed sites from the rest of the body. According to Maximov (1906), polyblasts may arise from fixed macrophages which possess the potentiality of wandering when under the influence of certain stimuli. According to Maximov and Bloom (1942), "when local inflammatory stimuli act upon the fixed macrophages in any type of connective tissue, they are transformed into free inflammatory macrophages or polyblasts." In the irradiated axolotl, the origin of the macrophages from the blood elements appears highly probable, but it would seem unlikely that any of these macrophages could arise from the connective tissue of the x-ray-treated regenerating limb. One possibility that cannot be excluded, however, is that some of them may come from the connective tissue of that part of the regenerating limb which was not directly x-rayed.

Numerous observations show that giant cells (polyblasts or phagocytes) occur in radiated areas of amphibians at the time of the primary acute reaction to irradiation (Brunst, 1944). When the inflammation and other phenomena of the acute reaction to irradiation are over, these cells disappear from the irradiated tissues Phagocytosis following irradiation has been found in insects (Carothers, 1940), amphibians (Litschko, 1935; Brunst, see above), and mammals (Tsuzuki, 1926; Kosaka, 1928). The giant cells described in guinea pigs by Torrioli and Florentino (1935) also may be phagocytes.

Reduction is not a reaction specific to regenerating limbs. The reduction phenomenon has also been observed in locally irradiated developing limbs of the axolotl, *Siredon mexicanum* (Brunst, 1938). The latent period after treatment with 5000 to 7000 r units was found to last for 2 to 4 weeks, during which time the limbs continue their normal development. This was followed by an arrest of the growth of these limbs, after which a typical reduction process ensued in 50 to 60 per cent of the individuals studied. In the axolotl the reduction process in the irradiated developing limbs is not distinguishable from an analogous process in irradiated regenerating extremities. Giant cells (polyblasts or macrophages) also are found in irradiated tissues of young developing organs (developing limbs in *Amblystoma*, Puckett, 1936; developing limbs in the axolotl, Brunst, 1938; growing tails and other parts of young axolotls, Brunst, 1944a).

Butler (1933) has studied the histology of irradiated regeneration buds in larval stages of *Amblystoma punctatum*. After a six-day latent period, a process of gradual dissolution of cartilage begins in the irradiated regenerating limbs. In the control animals, a rapid differentiation of the skeletal elements begins at about the same time that dissolution starts in the irradiated animals. The disintegration of the cartilaginous skeleton proceeds in the proximal direction. The cells composing the core of the regeneration bud disappear, leaving the bud empty. In the opinion of Butler, based on his study of the larvae of *Amblystoma punctatum*, the x-rays effect first of all the differentiation of the regeneration blastema. In the absence of differentiation, which was suppressed by irradiation, the dedifferentiation process destroys the cartilaginous skeleton and other tissues. Puckett (1934, 1936) also observed dedifferentiation of all tissues after irradiation of *Amblystoma* larvae. Butler and Puckett (1940) have claimed that: "Excessive dedifferentiation is not a direct effect of radiation. The hypothesis is proposed that dedifferentiation normally is checked through activity of the blastema. When the blastema is inactivated then dedifferentiation remains unchecked and proceeds to great extremes" (p. 237).

Obviously the process of unlimited dedifferentiation in larval stages of *Amblystoma punctatum* and in tadpoles of *Rana sylvatica* after x-ray treatment (Butler, 1933; Puckett, 1934, 1936, 1937; Butler and Puckett, 1940) and the reduction process following x-ray treatment of regenerating limbs in *Triton cristatus* and the axolotl *Siredon mexicanum*, as well as the reduction of young developing organs in the axolotl, are identical phenomena. Puckett (1936) described "giant" cells but did not ascribe to them any particular significance. He said: "Cells in mitosis show especial peculiarities; such cells become many times larger than the normal and form what might be termed 'giant cells'. . . ." (p. 187). "Figure 20 shows a few cells remaining, among these a large 'giant cell,' in this case many times larger than the normal mesenchyme cell" (p. 188).

The reduction process may thus be regarded as a primary acute reaction to irradiation of organs that consist of relatively young, undifferentiated, and rapidly dividing cells. Such cells are more sensitive to irradiation than differentiated ones, as Bergonié and Tribondeau pointed out as early as 1906.

It should be noted that in amphibians the process of reduction may be provoked by means other than x-ray treatment. For example, a reduction of regenerating limbs in *Triton* has been observed following destruction of their innervation (Schotté, 1926; Brunst, 1926). Similar results were obtained in larvae of *Amblystoma punctatum*, *Amblystoma opacum*, and *Triturus viridescens* (Butler and Schotté, 1941; Schotté and Butler, 1941).

C. *Effect of irradiation prior to amputation (treatment of the adult extremity)*

According to Schaper (1904) and Puckett (1936), the tissues of an adult organ are less sensitive to irradiation than the tissues of a regenerating structure. As other investigations have shown (Brunst and Scheremetjewa, 1933; Brunst and Chérémétieva, 1935; Scheremetjewa and Brunst, 1935; Brunst, 1938, 1944) adult organs react to irradiation differently from regenerating ones. No reduction is ever observed in irradiated adult organs. But if very large doses are used, necrosis may be observed. A characteristic feature of x-ray induced necrosis is the injury of the integument. Therefore necrosis always begins with the formation of open wounds. The soft tissues of the limb or the tail rapidly disintegrate and fall off piece by piece. Naked skeletal elements fall off gradually. Necrosis may begin in the distal as well as in the proximal part of the organ, and progresses rapidly. The entire distal part eventually falls off. However, after treatment with the same dose of x-radiation, necrosis of adult limbs occurs much less frequently than does the reduction of regenerating limbs.

It is reasonable to suppose that the further the development of a regenerating limb has proceeded, the more its reaction to irradiation will be similar to that of an adult limb. Irradiation of regenerating *Triton cristatus* at different stages, i.e., with different numbers of toes, produced approximately the same results in all stages (Brunst, 1938). It was concluded that the transformation of a regenerating limb into an adult extremity takes place long after the formation of the complete number of toes. Experiments have been performed with *Triton cristatus* in which nine-months-old regenerating and adult limbs were treated with x-rays. The proportion undergoing reduction was much lower than in younger regenerating limbs, being only 25 per cent instead of 95 per cent (Brunst, 1938). Thus, the reaction of a nine-month-old regenerating limb approaches, yet does not quite equal, the reaction of adult limbs.

The amount of radiation which destroys the capacity of an adult limb to regenerate in triton or axolotl usually produces no visible changes in it. In many experiments, stumps of irradiated extremities consisting of adult tissues have persisted for long periods of time without showing any ability to regenerate (Brunst and Scheremetjewa, 1933; Scheremetjewa and Brunst, 1935, 1937; Brunst, 1938). One could infer that a whole limb could still exist although its regenerative capacity had been destroyed. A massive dose of x-rays (15,000 r, 7000 r, or 4000 r) was given to the proximal part of triton limbs. The irradiated limbs retained their normal appearance, movements, and cutaneous sensitivity. No apparent differences between the irradiated and the control limbs of the same animal were perceived. An amputation of both legs, control and treated, was performed two months after irradiation. Despite the similarity in appearance of the limbs before amputation, no regeneration was observed on the irradiated side, while the control limbs regenerated normally (Brunst and Sheremetieva, 1937). These results show that an irradiated organ may remain alive despite loss of its capacity to regenerate.

According to Luther (1939), in irradiated salamander larvae the differentiated skin cells are not injured by x-rays, but all processes of cell division are completely blocked. This author has given much significance to the fact that cells which normally divide every 3 to 4 days may, after irradiation, continue for months without dividing. According to Osgood (1940), the "action of irradiation is to prevent the onset of mitotic or amitotic division and not by directly killing cells."

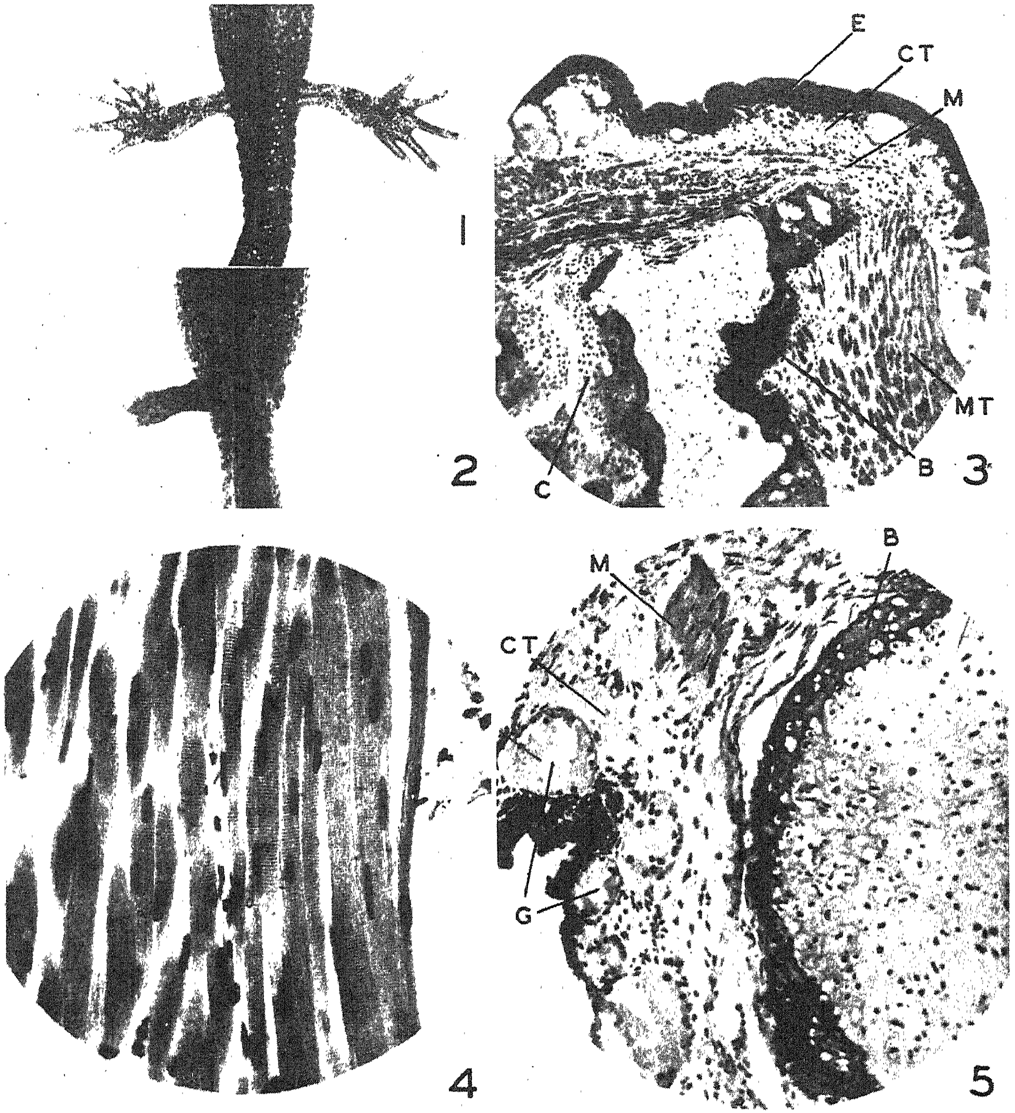

FIG. 8. INHIBITION OF REGENERATION IN X-RAYED ADULT LIMBS OF TRITON CRISTATUS

1. Posterior limbs of triton, one year after the irradiation of the proximal portion of the right limb with 7000 r.
2. The region of the posterior limbs in the same animal 90 days after amputation of both limbs at equal distances from the body.
3. Part of a longitudinal section through a regenerating limb five months after amputation and eight months after irradiation with 7000 r. E, epithelium over stump of amputation; B, bone; C. cartilage; MT, muscle tissue; CT, connective tissue; M, muscle fibers growing into connective tissue. × 50.
4. Another part of the same section. Muscle tissue. × 400.
5. Part of a section through the proximal region of the right posterior limb 5 years and 64 days after irradiation with 3750 r, and two years after a second amputation in the same region. The first amputation was made after irradiation. SG, subcutaneous glands; CT, connective tissue; M, muscle tissue; B, bone. × 50. (After V. V. Brunst, 1938a, 1944).

Similar results have been obtained in a number of invertebrates; irradiated organisms remained alive for a variable period of time, although cell division and regeneration were suppressed (in *Tubularia crocea*, Curtis and Ritter, 1927; in *Planaria*, Weigand, 1930; in *Tubifex*, Stone, 1932; in *Lumbriculus*, Turner, 1935). Irradiated trypanosomes were found to retain their mobility but to lose their ability to divide (Halberstädter, 1914). Irradiated *Polonium* and *Polytoma* (Protozoa) also retained their mobility and ability to grow, but no division was observed after treatment (Holweck and Lacassagne, 1931). The division of *Paramaecium caudatum* is suppressed by two-thirds of the lethal dose of x-rays. The treated individuals continue, however, to live, and, furthermore, increase in size (Back, 1939). Irradiation does not kill the spermatozoa of *Arbacia*. They move normally and fertilize the eggs. It is not until the first cleavage stage that it is possible to observe the effects of x-ray treatment (Hertwig, 1911; Henshaw, 1940). The results of all these experiments show that the amount of treatment sufficient to suppress proliferation differs considerably from the lethal dose, being much less (see also Belluci, 1939; Packard, 1945).

Two possibilities arise with the passage of time. First, if the irradiated extremities remain alive for very long periods (a year or more), very late radiation reactions may conceivably arise. Second, the regeneration capacity might be restored, at least partly, after a certain lapse of time. The first possibility is particularly likely because of the paradoxical cases of delayed reaction to irradiation described by Matas (1925). According to him, a lethal gangrenous dermatitis in a man was observed four years after irradiation. The following experiment was therefore performed upon *Triton cristatus* (Brunst and Scheremetjewa, 1937a). In several individuals the right hind limb was irradiated with 7000 r units. For one entire year no difference was to be observed in the appearance or function of treated and control limbs (Fig. 8, 1). After the amputation, regeneration took place normally on the control side but was suppressed on the irradiated side (Fig. 8, 2). These experiments suggest that the alterations caused by irradiation in adult tissues are permanent. Despite the unimpaired viability of the limb, its regeneration capacity had been entirely destroyed. The altered properties of the limb became manifest only after the amputation, when a regeneration blastema should normally be formed. After the year period (one year in triton's life being equivalent to not less than four in the life of a person) no delayed reaction analogous to that described by Matas, and no restoration of regenerative capacity was observed.

Histological examination of the stumps of *Triton cristatus* made after more or less prolonged time intervals following irradiation has shown that after a sufficiently heavy treatment tissue regeneration is also suppressed (Brunst, 1938, 1944). As an example may be cited the structure of the distal part of a stump of triton irradiated with 4000 r-units of x-rays. Three months after the treatment, the limb was amputated, but no regeneration was observed. Eight months after the treatment another amputation at a more proximal level was made. Histological study of the amputated piece showed the plane of the first amputation to be clearly visible, as the distal edge of severed bone remained without change and showed no sign of regeneration of bone or cartilaginous tissues (Fig. 8, 3). The distal surface of the non-regenerating stump was covered with a normal epithelium, under which was a small amount of connective tissue, and a few striated muscle fibers and blood vessels. The appearance of the treated tissues does not differ from that of the control animals. The striated muscles possess typical cross striations and longitudinal fibers, and the nuclei look normal (Fig. 8, 4). Mitotic figures were not found in any tissues, except the epithelium. Numerous normal mitotic figures were observed in the latter. However, despite the mitotic activity in the epithelium, no regenerative blastema was formed. Such irradiated tissues retain their normal appearance for an unlimited time. For example, normal-looking tissues were found in an animal that had lacked regeneration capacity for five years and 65 days after the irradiation. No regeneration took place in this animal after two successive amputations. The skeleton of the limb was shortened to the proximal epiphysis of the femur (Fig. 8, 5). The amputation site was covered with skin containing normally developed subcutaneous glands. No mitoses were found (Brunst, 1938, 1944).

Many authors have pointed out that no visible structural changes are seen in the irradiated tissues, and that nevertheless the cells of these tissues have lost the ability to divide and the organs their ability to regenerate. Thus, a histological study of treated septa of *Tubifex* showed no visible alterations, although they had lost the ability to form neoblasts (Stone, 1932). No changes in somatic cells have been found in planarians dying one month after irradiation. Mitotic figures were, however, absent; and sex cells showed signs of degeneration (Bardeen and Baetjer, 1904). Within a certain range of doses of radiation, rat spermatozoa remain morphologically normal and yet are incapable of giving rise to viable offspring (Wattenwyl, 1941).

D. Comparison of the influence of x-rays on the tissues of adult limbs and on the tissues of regeneration buds

As has been shown above, irradiated and control adult limbs do not differ materially in histological structure. The lack of growth in the tissues of adult control limbs, indicated by exceedingly rare mitoses, is responsible for the fact that no difference was observed in the histological structure of untreated and irradiated limbs. It is especially interesting to compare the structure of a control regenerating bud, normally having many mitotically dividing cells, with a radiated regenerating bud. The irradiated buds stop growing and usually undergo a process of reduction, but in rare instances no reduction takes place. Examination of such nonreducing buds revealed the following: a 2 mm. long bud, preserved two months after a heavy treatment (15,000 r), was covered with a single layer of epithelium; the distal end of the severed bone showed a slight proliferation of cartilage, formed, presumably, during the postradiation latent period; the entire regeneration bud was filled with loose connective tissue; prochondral tissue was lacking; and not a single mitosis was found (Fig. 9, 1). Another regenerating bud, 1.3 mm. long, preserved a year after amputation and two years after irradiation with 3,750 r, was filled with loose connective tissue and a few muscle fibers. The bud was covered by typical old skin with a well developed connective tissue layer and subcutaneous glands (Fig. 9, 2). No mitoses were found (Brunst, 1938, 1944).

Such pictures may be compared with that found in the normal regeneration process. For example, a 26-day-old regenerating bud, 3.2 mm. long, was covered by epithelium with subcutaneous glands in process of formation; a strand of prochondral tissue extended from the distal end of the cartilage to the tip of the regeneration bud; and many mitoses were found in the epithelium, prochondral tissue, cartilage, and connective tissue. The whole regeneration bud was in the midst of rapid growth (Fig. 9, 3).

Thus the effect of x-rays on regenerating or on adult extremities manifests itself as a complete suppression of cell division.

THE SOURCE OF CELLS FOR THE REGENERATION BLASTEMA

The following three hypotheses concerning the origin of the cellular constituents of the regeneration blastema have been suggested. First, the regeneration blastema is formed exclusively by mobile elements derived from the blood stream (hematogenic origin: Colucci, 1886; Fritsch, 1911). Second, the origin of the regeneration blastema is mixed, being derived from blood as well as from local tissue cells (histo-hematogenic origin: Hellmich, 1930; Kazancev, 1934; and others). Third, the regeneration blastema is formed exclusively from local cellular elements (histogenic origin: Weiss, 1925; Böhmel, 1929; and others).

Hertwig (1927) transplanted limbs of haploid triton larvae into diploid larvae of the same age. After the establishment of the transplants, amputations were made. The regenerating bud consisted sometimes of diploid, sometimes of haploid, and sometimes of mixed cells. According to Hertwig, formation of the regeneration blastema can take place, in cases when the local materials are inadequate, at the expense of cells derived from incoming wandering elements.

Studies of the effects of x-rays on regeneration shed light on the problem of the origin of the regeneration blastema. Normal regenerating structures have been observed during the survival period in individuals given a lethal dose of general body irradiation with x-rays, provided that the regeneration bud was protected from the rays by leaded rubber (Litschko, 1930, 1934). It has already been pointed out above that the regeneration capacity of *Triton cristatus* limbs is entirely destroyed by local irradiation (Brunst and Chérémétieva, 1936). These facts argue in favor of a local origin of the regeneration blastema.

The experiments which are most conclusive in this respect are those in which the regeneration capacity was destroyed in a part of a limb and preserved in another part of the same limb (Brunst and Scheremetjewa, 1937a). The proximal part of a limb of *Triton cristatus* was irradiated with 7000 r units, and part of the distal portion was then amputated. Regeneration took place in the part which was not directly irradiated, although this part received its blood and nerve supply through the irradiated portion. In all treated animals, without exception, completely normal regeneration took place, differing in no way from the

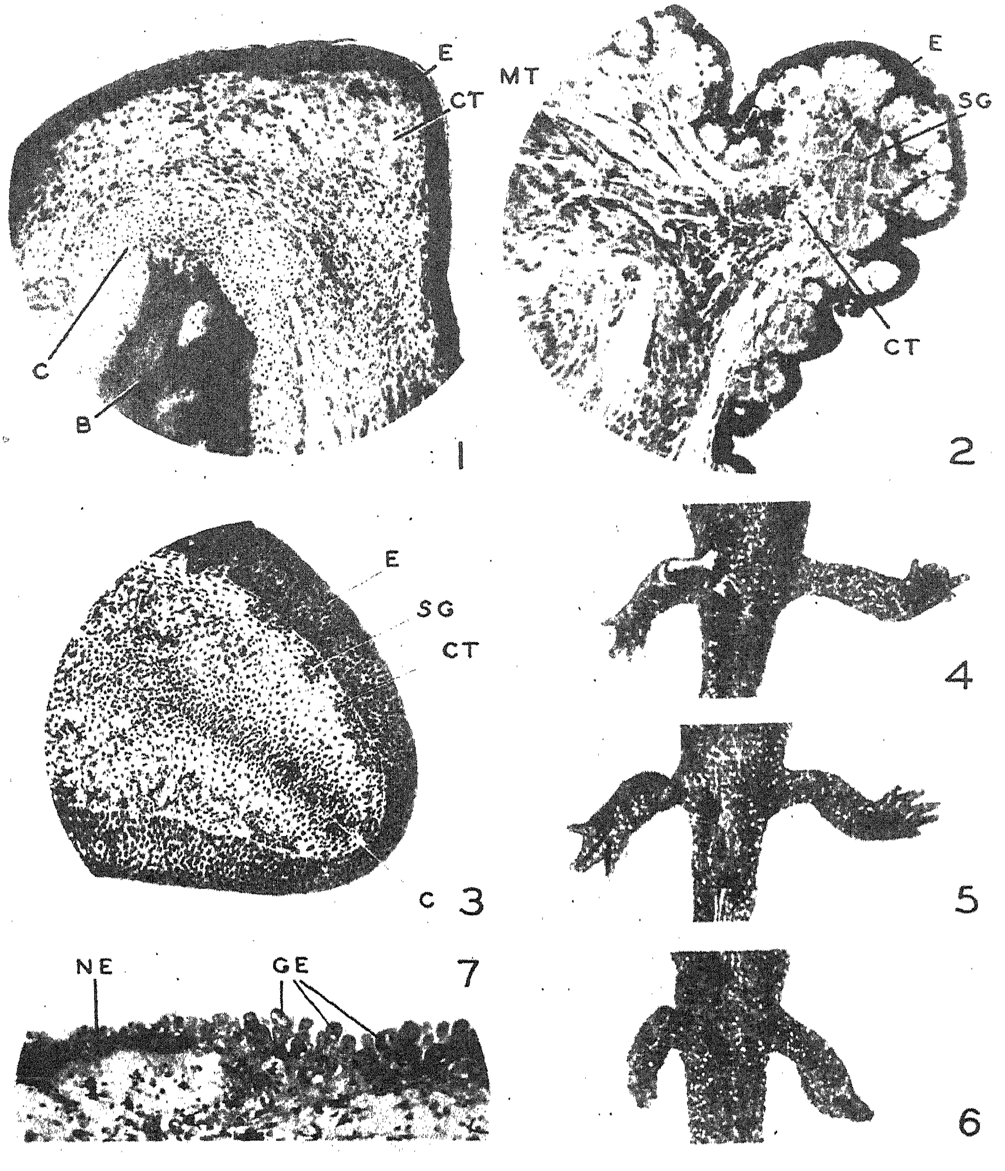

FIG. 9. INHIBITION OF GROWTH OF A REGENERATIVE BUD BY X-RAY TREATMENT AND LOCAL ORIGIN OF A REGENERATIVE BLASTEMA IN TRITON CRISTATUS; PATHOLOGICAL MODIFICATIONS OF CELLS CAUSED BY X-RAYS IN A TADPOLE OF PELOBATES FUSCUS

1. Part of a section through a regenerative bud of triton two months and 13 days after amputation and one month and 18 days after irradiation with 15,000 r. E, epithelium; B, bone; C, cartilage; CT, connective tissue. × 50.

2. Part of a section through a regenerative bud of triton one year after a fourth amputation and two years after irradiation with 3750 r. Irradiation one month after first amputation. E, epithelium; MT, muscle tissue; CT, connective tissue; SG, subcutaneous gland. × 50.

3. Part of a section through a normal regenerative bud of a triton limb 26 days after amputation. E, epithelium; SG, subcutaneous gland; CT, connective tissue; C, young cartilage tissue (prochondral tissue). × 50.

4. Region of the posterior limbs of triton four months after irradiation of the proximal part of the right limb with 7000 r, ventral aspect (right limb is on the left side of the figure). The *femur* is broken and protrudes through soft, necrotic tissues of the treated part. Normal regeneration (three months after amputation of both limbs) in the distal part.

5. The same, two months and 10 days later. Necrosis has ceased, and the wound is covered with epithelium. Ventral aspect.

6. The same, three months and 12 days later. Normal regeneration 59 days after second amputation of both limbs in the distal part. Ventral aspect. (After V. V. Brunst, 1938).

7. Tail epithelium after irradiation with 3750 r in a tadpole of *Pelobates fuscus*. NE, normal epithelium; GE, pathological (giant) epithelium. × 116. (After E. A. Scheremetjewa and V. V. Brunst, 1933).

situation on the control side. In consequence of such a large dose as 7000 r units, necrosis of the irradiated part of the limb was observed in a few of these animals. Most noteworthy was one specimen in which the proximal part of the limb was so severely injured that it became necrotic, and the *femur* broke and protruded (Fig. 9, 4). Two months later, the necrotic process had stopped completely, and the wound was completely epithelized. The limb was at this time joined to the body only by a thin, soft stalk. Though it did not move, it preserved normal sensitivity. Despite the severe disturbance in the proximal portion, regeneration of the distal part took place quite normally (Fig. 9, 4 and 5; Fig. 10). Regeneration occurred normally also after a second amputation of the distal part (Fig. 9, 6).

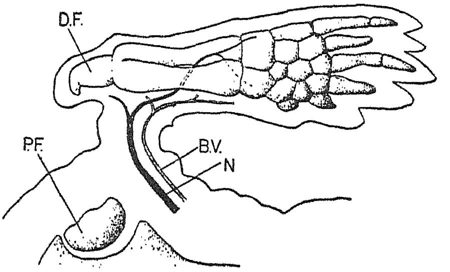

FIG. 10. LOCAL ORIGIN OF A REGENERATIVE BLASTEMA IN TRITON CRISTATUS

Reconstruction of the skeleton, nerve, and blood vessels of the irradiated limb shown in Fig. 9 (4–6), fixed for examination after the end of experiment. DF, distal epiphysis of femur; PF, proximal epiphysis of femur; N, nerve; BV, blood vessel. (After V. V. Brunst, 1938).

The regeneration capacity in *Triton cristatus* may be destroyed by a local x-ray treatment simultaneously in the proximal and distal parts of a limb, but may nonetheless be preserved in a small intermediate section, in the region of the knee joint, that has been protected from the radiation (Scheremetjewa and Brunst, 1938). No regeneration was observed subsequently, either when an amputation was made in the distal irradiated part or in the proximal irradiated part. Yet completely normal regeneration was observed following amputation through the middle section (Fig. 11).

Conversely, after irradiation of the knee-joint region in larvae of *Eurycea bislineata* (Butler and O'Brien, 1942), normal regneration was observed in the distal and proximal parts of the limb, but none occurred when the amputation was made in the region of the knee joint (Figs. 12, 13).

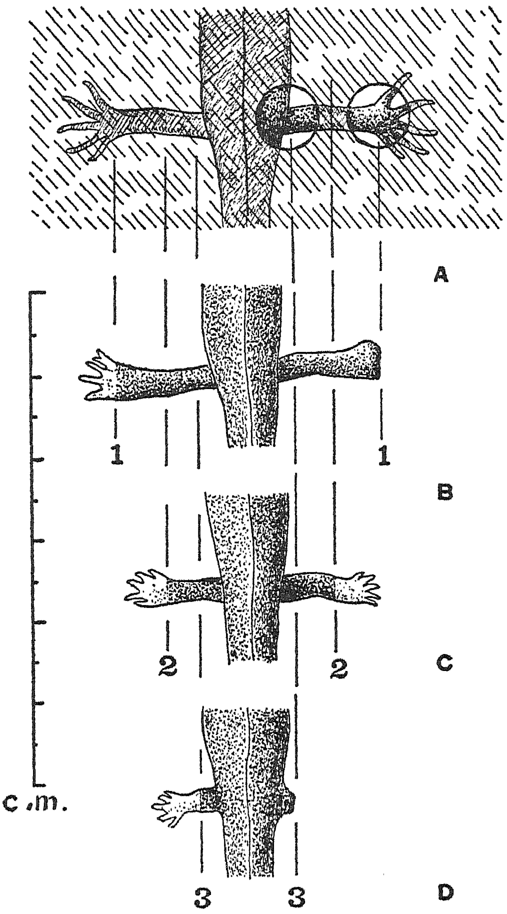

FIG. 11. LOCAL ORIGIN OF A REGENERATIVE BLASTEMA IN TRITON CRISTATUS

Schematic drawing of hind limb region made from successive photographs of the same animal.

A. Irradiation of the proximal and distal parts of the right limb, the two rings showing the position of localizing openings during the irradiation. The hatching symbolizes the lead cover protecting the remainder of the body from the x-rays. The broken lines (1, 2, 3) show the positions of the three successive amputations of the limbs.

B. The results of irradiation of the distal part of the right limb and protection of left one. 118 days after treatment and 100 days after the first amputation of both limbs in the distal portion.

C. The results of protection of the middle part of the right limb and the entire left limb. 253 days after treatment of the proximal and distal parts of the same limb and 109 days after the amputation of both limbs in the middle portion.

D. The results of irradiation of the proximal part of the right limb and protection of the left one. 379 days after the treatment and 70 days after the amputation of both limbs in the proximal portion. (After E. A. Scheremetjewa and V. V. Brunst, 1938).

Transplantation of a normal regeneration bud into an irradiated limb gives normal regeneration (Butler, 1935). Conversely, irradiated regeneration buds which failed to grow in their original location failed to develop in the new location as well, when transplanted into normal, untreated limbs (Brunst, 1938).

The results of all these experiments with x-ray irradiation agree completely with the theory of regional autonomy of the regeneration process. According to this theory, the characteristics of a regenerating structure in the *Amphibia* do not depend upon the organism as a whole, but are determined by the properties of the part that gives rise to the regenerate. The regenerative blastema is formed entirely from local cellular elements (Weiss, 1927; Vallette, 1929; Guyénot and Ponse, 1930; and others).

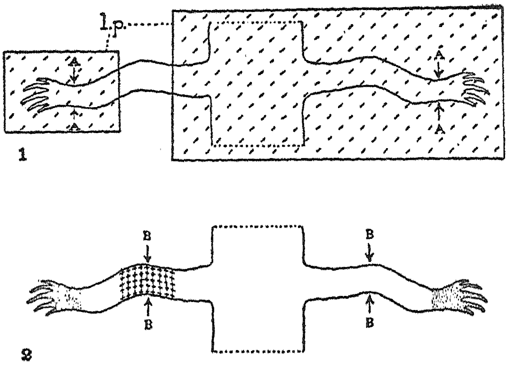

FIG. 12. LOCAL ORIGIN OF A REGENERATIVE BLASTEMA IN EURYCEA BISLINEATA

1. Diagram of arrangement for localized irradiation. l.p, lead plate. Arrows (A) indicate level of first amputations.

2. Same larva 3 weeks after radiation and first amputations. Arrows (B) show level of second amputations. (After E. G. Butler and J. P. O'Brien, 1942).

MODE OF ACTION OF X-RAYS IN SUPPRESSING REGENERATION

The fact that x-rays suppress the regenerative process is, then, well established. But the mode of action of this agent is still not clear. The x-ray injury of the treated organ is obviously a subtle reaction, since these injuries allow the treated organ to stay alive for considerable period of time. The irradiated limb differs obviously from the normal in one way only, namely, in that it lacks regenerative capacity. This subtle but irreversible, table alteration can be induced by some influence of x-rays either on cell structure or cell metabolism, or upon both. Therefore, in order to approach an understanding of this problem, the results of numerous investigations in this field have to be considered. Despite the great number of papers dealing with this problem, no complete agreement has been achieved until recently.

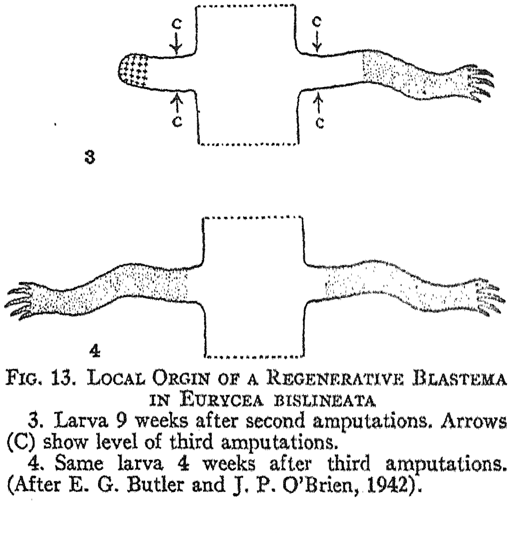

FIG. 13. LOCAL ORGIN OF A REGENERATIVE BLASTEMA IN EURYCEA BISLINEATA

3. Larva 9 weeks after second amputations. Arrows (C) show level of third amputations.

4. Same larva 4 weeks after third amputations. (After E. G. Butler and J. P. O'Brien, 1942).

Some investigators have regarded the nuclei and mitotic mechanism as most sensitive (Bergonié and Tribondeau, 1906; Bardeen, 1909; O. Hertwig, 1911; P. Hertwig, 1911; Payne, 1913; Grasnick, 1917; Packard, 1914, 1915, 1918; Mohr, 1919; G. Hertwig, 1920; Alberti and Politzer, 1924; Reiss, 1925; Tschassownikow, 1928; Politzer, 1930; Spear, 1932, 1946; Fuchs and Politzer, 1932; Mottram, 1933; Combs and Gravett, 1937; Luther, 1939a; Wottge, 1939; Petrova, 1942; Lavedan, 1945; Lea, 1947; and others). Others have found the cytoplasm to be most sensitive (Nürnberger, 1923; Weil and Frenkel, 1926; Jansson, 1926; Jasvoin, 1926; and others). The sensitivity of mitochondria has been emphasized by Wail and Liberson (1926), Nadson and Rochlin (1933), Joyet-Lavergne (1938), and Del Buono (1940). When observed in vivo, the cell nucleus seems unaffected by x-rays, while the cytoplasm is clearly altered (Jansson, 1927). Profound changes in the nucleus soon arise, particularly at mitosis. Packard (1931) reached the following conclusion: "Although we can detect changes in one part of the cell before some other portion is altered, this is not proof that the one is more severely damaged than the other, nor can we judge the extent of the injury by the appearance of the cell at any particular moment. One that is to all appearances moribund may recover, while another that looks normal after exposure may die later" (p. 256). The changes noticeable in the cytoplasm are reversible (Caspari, 1926; Packard, 1926), and the mitochondria and Golgi bodies broken down by the irradiation are reformed (Hirsch, 1931; Fogg and Wanen, 1937). If, however, the alternations in the cytoplasm produced by very heavy treatment are too great, they become irreversible, and the cell dies (Ralston, 1939; Petrova, 1942). According to Henshaw (1938), Ralston (1939), and others, the suppression of the ability of cells to divide depends upon changes in the nuclei.

In analogy with the arrest of body growth conditioned by the abnormal metabolism that is caused by pathological changes in the endocrine apparatus, it can be supposed that x-rays acting on the cell lower the metabolic rate in the treated organ to such an extent that no cell division, and consequently no growth, can take place.

As to the influence of x-rays on metabolism there are the following opinions. Some authors have concluded that irradiation reduces the rates of respiration and glycolysis (Bersa, 1927; Adler, 1930; Grabtree, 1932; Bodine and Evans, 1934; Evans, 1934; Joyet-Lavergne, 1938; Provenzale, 1942; and others). Others found an increase in the respiration rate (Kimura, 1919; Heeren and Pansdorf, 1931; and others). Still other investigators have considered x-ray effects on metabolism to be unproven (Holthusen, 1921; Boell, Ray, and Bodine, 1937; Goldman, 1943; and others). Krontowski and Lebensohn (1932) treated tissue cultures with radium and found that despite the suppression of growth in irradiated tissue cultures, the rate of glycolysis remained at about 80 per cent of normal. Particularly important is the conclusion of Erdman (1934) that growth always stops before there is a drop in the metabolic rate. Chesley (1934) came to an analogous conclusion. He pointed out that abnormalities in embryonic development appear before the decrease in respiratory rate. The same author showed that eggs of *Arbacia* and *Chaetopterus*, the development of which had been arrested by x-ray treatment, did not show changes in respiration rate.

Finally, some observations on pathological modifications of cells caused by x-ray treatment in different tissues of various organisms, such as algae (Pietschmann, 1937), insects (Mohr, 1919; Helwig, 1933; Dererer, 1940), amphibians (Scheremetjewa and Brunst, 1933; Brunst, unpublished), and mammals (Maximov, 1923), show that the individual cells continue to grow in size despite suppression of their mitotic activity. These cells become quite large and frequently possess two or several nuclei (Fig. 4, 3 and Fig. 9, 7). Perhaps the binucleate cells described by many authors in irradiated tissues are incipient cells of such a kind (Afanassieva, 1936; Atabekova, and others). The increase in cell size may possibly be explained on the basis of an active metabolism (see also Back, 1939). According to Lavedan (1945), most investigators are inclined to think that x-rays scarcely affect metabolic processes. Lamarque's opinion (1942) is that if metabolic changes are observed following large doses of x-rays, this is to be interpreted not as a direct effect of the rays but as a result of injuries to the cells. Obviously the changes that some investigators have observed in the metabolic rates following x-ray treatments are not the primary causes of the other responses of the organism to irradiation.

It appears that only one hypothesis explains most of the well established facts. If the dosage of x-rays is not high enough to kill the cells outright, no irreversible lethal changes are produced in the cells. However, subtle irreversible changes are produced which result in the suppression of mitosis. The mechanism of this process cannot be elucidated now. Its explanation will require a much more detailed knowledge of the delicacies of the structure of the living cell, as well as a much more profound understanding of the nature of the biological effects of x-rays.

It is possible that recent investigations of the action of x-rays upon the nucleic acid metabolism of cells may be an aid in the solution of this problem. It has been found that x-rays inhibit nucleic acid metabolism. Furthermore, it is significant that nucleic acid metabolism plays a fundamental role in mitotic division. This may explain the suppression of mitotic activity by x-ray irradiation (Mitchell, 1943; Stowell, 1945; Taylor, Greenstein, and Hollander, 1947; and others).

THE INFLUENCE OF X-RAYS ON GROWTH AND DIFFERENTIATION DURING REGENERATION

One of the oldest and most important generalizations in the field of x-ray biology is the law of Bergonié and Tribondeau (1906), which states that x-rays have the greatest effect on cells with a high reproductive capacity and that are least differentiated, and thus more like the embryonic cell types. Thus immature sex cells are among the most sensitive. The literature dealing with x-ray effects on sex cells is enormous. Among the classic studies in this field are those of Bergonié and Tribondeau (1904, 1906a, b) and others. The sensitivity of undifferentiated cells to x-rays has been pointed out by many authors (Hertwig, 1911; Curtis and Hickman, 1926; Stone, 1932; Turner, 1935; Scheremetieva, 1937; Greite, 1940; Evans, 1941; and others). According to these authors, the sensitivity of tissue is dependent upon the degree of its differentiation and the mitotic activity of the constituent cells. Tissues and organs have been graduated according to their x-ray sensitivity by various authors as follows (Table 1):

TABLE 1

Degrees of sensitivity of tissues to X-rays

RIEDER ROSENTHAL 1922	SCHEREMETJEWA AND BRUNST 1933	CLARK 1934	ELLINGER 1941
			1. Lymphoid cells
1. Epithelium	1. Epithelium	1. Epithelium	2. Epithelial cells
2. Connective tissue	2. Connective tissue	2. Blood vessels	3. Connective tissue cells
3. Muscles	3. Muscles	3. Connective tissue	4. Muscle cells
4. Blood vessels	4. Nerve	4. Muscles	5. Bone cells
5. Nerve		5. Nerve	6. Nerve cells

The most detailed picture of the radiation sensitivity of various tissues and organs has been given by Warren (1936). According to this author the bone-marrow cells, intestinal crypt epithelium, lymphocytes, and lymphoid structures have the highest sensitivity. The gonadal cells, especially the immature forms, are only slightly more resistant. A moderate sensitivity characterizes the thymus, the stomach, colon, bladder and salivary epithelia, blood vessel endothelium, and connective tissue cells. Next in order of sensitivity are: the mucosa of the mouth, esophagus, rectum, vagina, pleura, and skin epithelium. The muscles, cartilage, bone cells, and stroma cells of testes and ovary are somewhat more resistant to radiation damage. Most resistant are: red blood cells, adult sperm cells, adult thyroid, adult pituitary, adult specialized connective tissue structures, brain and nerve cells. The most highly differentiated cells which are incapable of dividing, for example, nerve cells, are thus most resistant. Ganglion cells are equally as resistant as those of the central and peripheral nervous system (Caspari, 1926; Zimmern and Chavany, 1931; Scheremetjewa and Brunst, 1933; Clark, 1934; Ellinger, 1941; Campbell, Stanley, and Novick, 1946; and others). On the contrary, embryonic nerve tissue is one of the most sensitive to x-rays (Bagg, 1920; Caspari, 1926; and others).

Age changes in the sensitivity of tissues have been indicated by many authors. The older the embryo, the more resistant its tissues become (Winkler-Junius and Plaats, 1929; Olivieri, 1921; Toumanoff and Veretennikoff, 1930; Moore, 1932; Henshaw, and Henshaw 1933; Scott, 1934; Millwee, 1934; Sheremetieva, 1937; and others). *Daphnia* eggs in the brood chamber are injured by very weak doses which have no effect on the mother (Snider and Kersten, 1935). Irradiation of 18-hour-old *Daphnia* embryos is lethal, while 32-hour-old embryos are only slightly injured by the same dose (Snider and Kersten, 1936). "The lethal dose for the freshly hatched axolotls (150 r) is only one half of the lethal dose for the animals that lived 20 days after hatching (300 r) and only one third of the lethal dose for the axolotls which lived for 30 days after hatching (450 r). The dose which is lethal for the freshly hatched axolotls, has no marked influence whatever upon the animals that survived for 30 days" (Sheremetieva, 1937, p. 162). Developing *Drosophila* eggs treated with 190 r units die, while the lethal dose for young larvae is 1300 r and for adults 100,000 r (Mavor, 1927; Packard, 1945). "In general, sensitivity during development decreases as the age of an individual increases" (Spear, 1946, p. 8). The only contradictory data known to the reviewer are those of Strangeways and Fell (1927), who state that 6-day-old chicken embryos are more sensitive than 25-hour embryos.

Some authors believe that the law of Bergonié and Tribondeau is generally valid, even though not applicable in some cases (Packard, 1931, 1945). Certain exceptions, like rapidly dividing bacteria and yeasts, are not really contradictory to this law. The high resistance of microorganisms and of cells in tissue cultures is a well established fact (Polzien, 1932; Gregori, 1938; Petrova, 1940; Doljanski and Goldhaber, 1942; Back and Halberstaedter, 1945; and others). According to Spear (1946), the dose necessary to kill 50 per cent of the samples of organisms or to reduce their growth to half that of controls is as follows:

Organism	*Doses in r units*
Eggs of *Calliphora*	40
Eggs of axolotl	50
Eggs of *Drosophila*	190
Eggs of *Ascaris*	1,000
Larva of *Drosophila*	1,300
Bacterium coli	5,100
Saccharomyces	42,000
Imago of *Drosophila*	95,000
Bacterium mesentericus	200,000
Colpidium colpoda	330,000

The real nature of these exceptions is not clear at present, because the mechanism of x-ray effects in organisms is still obscure. It would appear that isolated cells are less sensitive than cells in a tissue (Schneider, 1926). Chemical substances which increase the sensitivity of an organism to irradiation have no effect in tissue cultures (Thomas and Chevroment, 1938).

The overwhelming weight of evidence on the effects of x-rays on multicellular organisms in vivo favours the Bergonié and Tribondeau law. As pointed out above, the cells are less sensitive the older and more differentiated they are. There appears to be some evidence, however, that x-rays may exert an effect on the processes of cellular differentiation also (Butler, 1933, 1935; Puckett, 1934, 1936a, b, 1937; Butler and Puckett, 1940). The basis of this view is that no differentiation processes take place after irradiation in a regenerating bud in an amphibian larva (Butler, 1933, 1935). Puckett (1936b) has studied the influence of x-rays on regeneration in the hydroid *Pennaria tiarella*, and came to the conclusion that x-rays suppress cellular differentiation without affecting cell multiplication. He found in irradiated hydroids large shapeless masses of cells which fail to regenerate new hydranths. It seems possible, therefore, that weak x-ray treatments may permit cell division to continue, although these cells may be sufficiently injured to disturb the morphogenetic processes. Such disturbances in morphogenesis and in growth have also been noted, following weak treatments, in regenerating amphibian limbs (Brunst, 1937). On the other hand, some observations support the view that processes of differentiation are not directly affected by x-rays. The differentiation of organs is completed after irradiation of chicken embryos (Vernoni, 1911). Likewise, no effect of irradiation on cell differentiation is recorded in mammalian testes (Hertwig, 1938). In the development of *Drosophila*, the resistance to irradiation is greatly increased at the time of gastrulation, which corresponds to the beginning of differentiation processes. The embryo at the time of differentiation is thus less sensitive to irradiation than during the processes of growth and cell division (Henshaw and Henshaw, 1933; Henshaw, 1935). In developing salamander larvae, x-rays completely suppress cell division but do not affect cell differentiation (Luther, 1939). In the x-rayed eyes of two-day-old rats, degeneration appears only in the undifferentiated layers of the retina (Spear, 1946). In the eye of the frog tadpole, where differentiation and proliferative activity are separated in space (the central parts being fully differentiated and functioning while proliferation still continues in the peripheral region), degeneration of cells was observed after treatment only in the peripheral germinative zone (Spear, 1946). From these experiments Spear concluded that "sensitivity to radiation is lost as differentiation proceeds"; and besides this he says, "in certain circumstances radiation may promote the process of differentiation" (p. 9). Studies of the influence of x-rays on the development of the axolotl show very clearly that x-rays do not interfere with the completion of tissue and organ differentiation, and yet suppress cell division and growth. This results in the formation of very small limbs (Fig. 14), whose growth has been arrested while the differentiation of their tissues was completed (Brunst, 1944a).

SUMMARY

1. Usually reaction of the organism to x-ray treatment is observed after a latent period. During this reaction, relatively acute and temporary changes in the treated tissues are observed (a "primary reaction"). Profound alterations of the

cells, particularly those in mitotic division, often cause pathological degeneration (visible injuries) and death of all cells with high sensitivity to x-rays. In many cases the reaction of irradiated tissues is similar to inflammation. In some cases the primary reaction is not observed, in spite of the fact that much later serious alterations in the treated organ may be detected. Some time after the primary reaction has occurred, a stable state, which lasts for an unlimited time, arises in the irradiated organs. The inflammation and all other phenomena characteristic of the primary reaction disappear before the establishment of this state. It may arise regardless of whether the primary reaction was acute, mild, or absent. The surviving tissues recover their normal appearance but not all of their potentialities (invisible injuries). Their cells have lost the capacity to multiply, and therefore regeneration, or further growth and development are impossible. This reaction has been called the "secondary reaction."

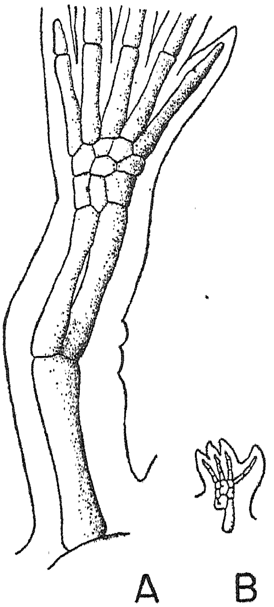

Fig. 14. The Lack of Effect of X-Ray Treatment on Differentiation of the Limb in the Axolotl, Siredon mexicanum

Reconstructions of the limb skeletons of the control (A) and of an irradiated animal (B) of the same age, at the same magnification. The inhibition of growth in the irradiated limb is accompanied by almost perfect differentiation of skeleton. (After V. V. Brunst, 1944 -a).

2. Postamputation irradiation of the regenerating limb causes not only an arrest of the regenerative process by usually induces a more or less rapid decrease in size, or reduction, of the treated regenerate. This phenomenon is due basically to an inflammatory process in the irradiated tissues. An active role in this process is played by giant cells (macrophages or polyblasts). These cells migrate to the irradiated zone, probably from the surrounding tissues. The tissues weakened by irradiation are destroyed by macrophages through phagocytosis and lysis. The reduction is a primary, acute reaction to irradiation in amphibian regenerates. It occurs also in developing limbs and tail of irradiated young amphibian larvae. The reduction is a reaction of young tissues to irradiation.

3. Irradiation prior to amputation (treatment of the adult limb) causes no reduction. Adult organs consisting of differentiated cells do not show the acute reaction. The irradiated organs do not differ in appearance from normal ones. However, these organs lose their ability to regenerate.

4. It is possible to destroy by means of local x-ray treatment the regenerative ability both in the proximal and in the distal portions of a limb, while preserving the regenerative capacity in a small intermediate, untreated portion of the same limb. Transplantation of a normal regeneration bud into an irradiated limb results in normal regeneration. Conversely, irradiated regeneration buds which have failed to grow in their original sites, will, when transplanted into normal, untreated limbs, fail to develop in the new location as well. The regeneration blastema is formed from local cellular elements.

5. If the dosage of x-rays is not high enough to kill the cells outright, no irreversible lethal changes are produced in them. A lethal dose for the cells is much greater than that which suppresses cell division, and hence growth, regeneration, and development. Irradiated cells suffer injuries, as a consequence of which they lose the ability to divide. But irradiated organs consisting of the cells which do not divide may persist without change for a very long time (a secondary stable state).

6. The suppression of cell division does not affect the differentiation process. Tissue and organ differentiation in irradiated animals may be completed despite a cessation of growth.

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SPECIATION IN ANCIENT LAKES

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INTRODUCTION

OUR knowledge of the geographical aspects of speciation is based primarily upon the distribution of species and subspecies of terrestrial animals, especially birds.

An observer on a broad continental area is accustomed to finding a single species occupying one particular ecological niche over that large area wherein the niche is available. Over some regions of the land surface the niches of a given kind are linearly arranged, as for instance in the narrow lowland strip between the mountains and the sea which makes up the greater part of the western coast of North America. In this geographical situation an observer is impressed by the fact that representatives of a species inhabiting the entire linear strip have a different appearance, depending upon which part or small section of the strip they live in.

The fox sparrows of North America illustrate the effect of the arrangement of habitats, in a way beautifully worked out by Swarth (1920). All the fox sparrows belong to a single species *Passerella iliaca*. Those of eastern North America breed over the entire forested area of Canada, and in Newfoundland and northern Alaska as well. Although differences can be noted between birds taken from the eastern and western ends of the range, they are minor and unworthy of nomenclatural recognition. All are considered to belong to the typical subspecies. Fox sparrows also find the west coast of North America habitable and breed from the proximal Aleutian Islands south to the Olympic Peninsula in Washington. Within this coastal strip there is considerable variation of the fox sparrows in coloration (from bright reddish-brown to clear gray), in relative lengths of feet and tail, and in size and shape of the bill. Six subspecies have been named from limited areas along this strip. However, there is complete intergradation between five of these subspecies, and those areas of transition from one subspecies to another within a short space are taken as the boundaries of adjacent subspecies. There do not appear to be any physical barriers within these regions of transition different from those within the range of any one subspecies. The fox sparrows which breed on Kodiak Island are different from either of the two subspecies on adjacent parts of the Alaskan Coast, from which they are, of course, isolated and constitute a separate subspecies *insularis*.

Aside from the northwestern corner of the state of Washington, which is inhabited by the southernmost members of this chain, the only zones habitable by fox sparrows in the western United States cover the upper slopes of mountains. These habitable areas become smaller and more isolated to the southward. The subspecies with the largest ranges are: *fulva*, which breeds throughout central Oregon and the northeastern corner of California; *mariposae*, whose breeding colonies are scattered throughout the north and central parts of the Sierra Nevada; and *schistacea*, which breeds in the Rockies from Alberta to Nevada and eastward into eastern Wyoming. The subspecies with more limited ranges occur to the south and the west of these wider-ranging subspecies: *brevicauda* breeds in a restricted area in the Coast Range in north central California; and *monoensis* and *canescens* are each confined to limited areas on the eastern slopes of the Sierra Nevada, in the central part of California near the Nevada border. The population of each of these two areas has diverged just enough to be recognized taxonomically, whereas the population of fox sparrows in several isolated mountain areas exhibit insufficient morphological distinctions and are grouped in the subspecies *stephensi*. References to the latter two types of habitat distribution, viz., the linear arrangement and the highly isolated types, are readily available in ornithological literature. Mayr (1942) has quoted several. One example to which I wish to direct attention is that of the lowland birds of New Guinea, whose habitat is the narrow strip encircling the central mountains. If Lake Baikal is conceived as being essentially similar to a water-filled cast of New Guinea, then the similarity of the horizontal and vertical zonation of the lake's benthic fauna to that of the island's fauna is not surprising (cf. p. 53).

The birds of archipelagos are classic examples of the second type of distribution, in which the habitats are widely separated. It is important that the essential features of distribution of the closely related species of an archipelago, such as the drepanids of the Hawaiian Islands, be borne in mind. The first feature is that obviously related populations on different islands may either be morphologically similar or may exhibit differences compatible with the assignment of subspecific or specific names, but usually they occupy the same or similar ecological niches. This is to be expected from observations of isolated habitats or clusters of habitats in continental areas. The group of lakes of the isolated Malili River of central Celebes is to the animals inhabiting the lakes what the islands are to the birds of an archipelago. The distribution patterns are entirely analogous.

The more striking feature of the Hawaiian drepanids is the fact that populations similar in general structure, nesting habits, and songs nevertheless exhibit profound differences in bill structure and feeding habits (Perkins, 1903). Trophic specialization in this one group of closely related birds has resulted in an array of bill structures which cannot be matched in any other family, or even in several taken together. Only among the closely related species of old lakes can comparable phenomena be found. Three lacustrine species flocks possibly exceed the drepanids in degree of trophic specialization. These are the cichlid flocks of the African lakes, Nyasa, Tanganyika, and Victoria. The most astonishing of these is the *Haplochromis* flock of Nyasa, with over one hundred species, most of which are only distinguishable on the basis of their mouth structure and pharyngeal teeth (Trewavas, 1935). The acme of trophic specialization is attained by the two Nyasan cichlid species of *Corematodus* whose diet consists solely of the small scales on the tails of certain other species of the same *Haplochromis* species flock (see Part II, section on Distribution and Speciation in Nyasa). The diversity of feeding habits associated with these structural differences has led some investigators to believe that a special kind of ecological speciation must have been involved.

It is the purpose of this paper to indicate that there is evidence that the principles of speciation derived from the study of terrestrial animals apply to the faunas of ancient lakes as well. The cichlid flocks in the African lakes are an extreme but comprehensible result of isolation and subsequent competition between closely related aquatic species, just as the drepanids are among birds (see Amadon, 1947). Although the general features of the evolution of lacustrine species flocks are apparently discernible, a tremendous amount of detailed information is necessary to test the validity of the hypotheses advanced and to serve as the basis for a more complete understanding of these spectacular evolutionary phenomena.

LAKE BAIKAL

The Baikal of today

Baikal is a long narrow lake lying with a northeast-southwest trend between 51° 43′ and 55° 46′N and 103° 44′ and 109° 37′E (Fig. 1). The long axis of the lake, which appears slightly curved on the map with its concavity towards the northwest, measures 674 kilometers. Its width varies between 25 and 74 km. (Fickeler, 1927). The lake occupies the bottom of a tectonic trough between nearly parallel mountain ranges which rise steeply from the lake shore except at the delta of the Selenga River. The area of the lake is 33,000 sq. km., and the area of the watershed is twenty times as large (Halbfass, 1928). This drainage is carried principally by three rivers, the Upper Angara, the Bargusin, and the Selenga. The Upper Angara runs NE from the northern end of the lake, draining the extension of the trough within which the lake lies. The Bargusin River empties into the middle of the east coast after draining a trough which parallels the northern half of the lake. The Selenga River, by far the largest of the lake's tributaries, drains the complex series of tectonic troughs and mountain ranges to the south and southwest of Baikal, emptying into the lake on the east shore about one-third of the way up from the southern end. The lower Angara, the lake's sole effluent, breaches the otherwise uninterrupted wall of mountains forming the west wall of the trough near the southern end of the lake and runs NW, joining the Yenesei River, which empties into the Arctic Ocean.

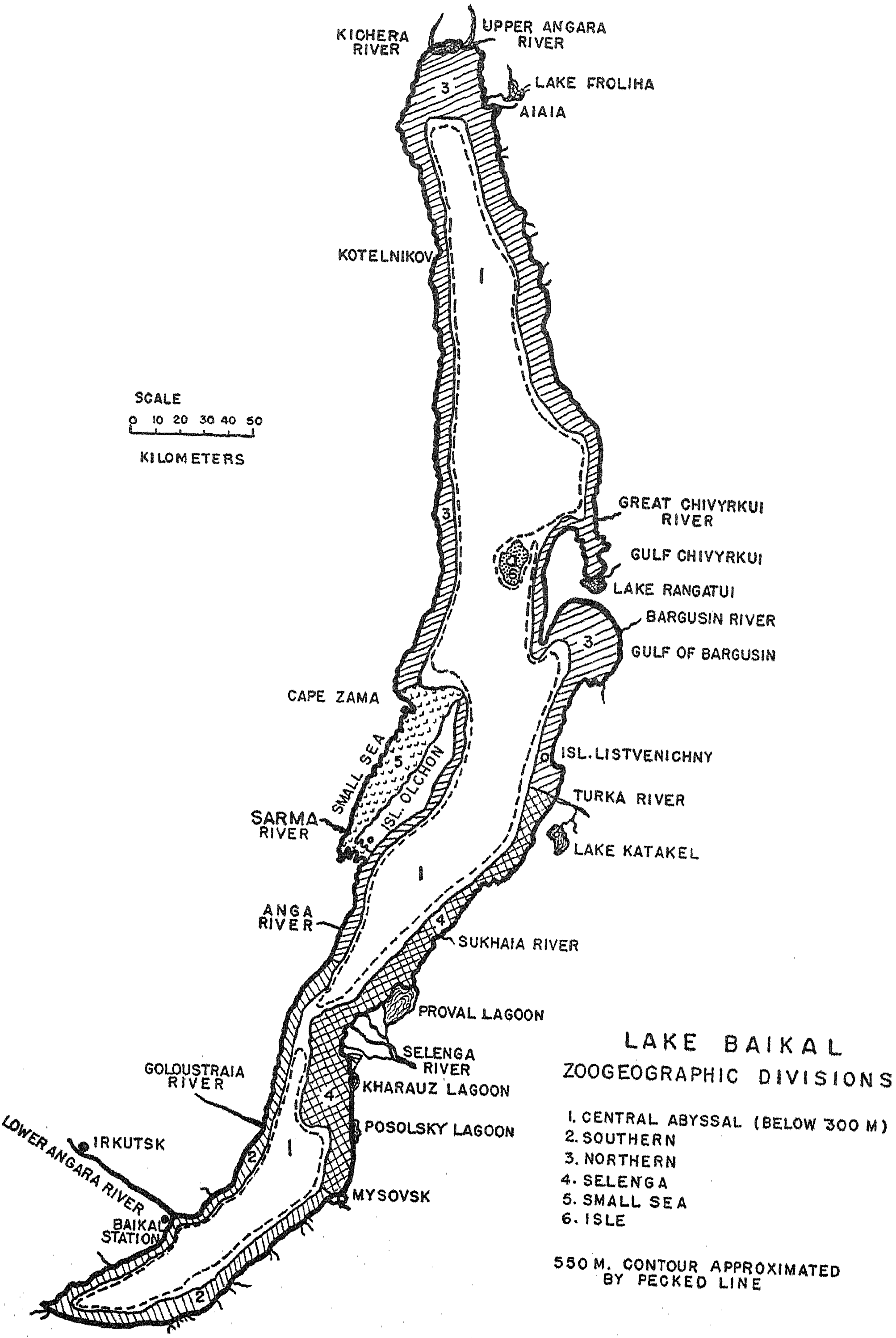


FIG. 1. ZOOGEOGRAPHIC DIVISIONS OF LAKE BAIKAL
(Based upon map in Dorogostaisky 1923, with 550 m. contour added from bathymetric map in Drizenko, 1908.)

The principal irregularities in the present coastline of Baikal are restricted to the central section of the lake. On the west the 75 km. long island of Olchon, separated at its southern end from the mainland by the narrow Strait of Olchon, forms the east bank of a long channel called the Small Sea. The peninsula Swajatoi-Noss, or Holy Nose, on the east shore encloses with its southern projection Bargusin Gulf, and with its northern, Chivyrkui Gulf. The Ushanii Islands lie just off the northern part of the Holy Nose. The only other major irregularity of the coastline is the Bay of Proval, adjacent to the Selenga delta on the northeast. This narrow stretch of water was formed by a sudden submergence of the land, toward the end of the last century.

Our knowledge of the bathymetry of Lake Baikal is based primarily upon the results of the Russian Hydrographic Expedition of 1896–1902. The surface is 462 m. above sea level. Three bathymetric regions are distinguishable. The southern basin, reaching a depth of at least 1441 meters, is separated from the middle basin by a ridge in the region of the Selenga delta. Vereščagin (reported by Halbfass, 1937) found a depth of 1741 m. in the middle basin, just off Olchon Island, proving Baikal the deepest lake in the world. North of the Ushkanii Islands the bottom is close to 800 meters deep throughout (Drizhenko's (1908) map, as reproduced by Fickeler, 1927).

A brief consideration (based largely on Fickeler) of the physics and chemistry of the lake water is necessary as a background to a study of the biota. The individual and total concentrations of various ions are within the ranges found in lakes of regions of external drainage. The distribution of temperature and oxygen in Baikal, the deepest lake in the world, is of greater importance. The temperature of the water below 250 m. is always between 4°–3.2°C., decreasing as the depth, and hence the pressure, increases. Twice a year, in late June and early December, the waters above 250 m. are also at 4°C. These are the periods of circulation, for the wind can mix the water to great depths when the density at all depths is very nearly the same. The waters above 250 m. are warmer than 4°C. from June until December, but at their maximum near the end of August the surface layers of the open water only reach 10°–15°C. Indeed, it is only the upper 5–10 m. which attain these temperatures. Below this superficial layer the amount of summertime warming is slight and decreases with depth. However, the surface temperatures in Chivykui and Bargusin Gulfs and the Small Sea may be as high as 20°C. in August, according to Dorogostaisky (1922). The waters all are well oxygenated to the greatest depth, so that the entire bottom is available for exploitation by aerobic organisms. At 1600 m. there was 6.77 cc./l. O_2 or 70% saturation at that temperature (Vereščagin, 1927, 1936).

In order for these deep waters to contain that much oxygen in the face of the continual, if slow, biological removal, they must be mixed with water which has been at the surface at times of circulation. Vereščagin (1936), as reported by Strøm (1945), is of the opinion that surface water can be fully circulated to a depth of 400–600 m. He further stated that partial circulation to 1000 m. is possible, but that the waters below this level are stagnant. However, it is impossible to see how water at 1600 m. can contain the amount of dissolved oxygen that it does, if the partial circulation does not extend to that depth.

Geological history of the Baikal basin

The most recent stratigraphic studies (Presniakov, 1940) indicate that all parts of the present basin were not formed at the same time. The southern basin is of Paleocene origin, at the youngest, and may have been in existence as far back as the end of the Cretaceous. This makes the maximum age of the lake between 50 and 75 million years (cf. Zeuner, 1946). The formation, or at least the deepening, of the rest of the present basin is associated with the crustal movements of the Pleistocene. The frequent earthquakes attest to crustal instability at the present time. Martinson (1940) has reported the results of his study of the microfossils of various lacustrine deposits encountered in the region adjacent to the eastern and southeastern coasts of the lake. Some of these beds had been exposed by erosion; others were sampled by deep borings. Analysis of the microfossils of these deposits has indicated that during the entire Tertiary, and possibly even earlier, the land adjacent to the south and middle basins was forested, indicating a relatively moist clinate. There is evidence of two types of freshwater basins within this forested area. One type was the shallow, often marshy lake whose fauna and flora were representative of that wide spread in the freshwater of Circumbaikalia. The other was the basin, or series of basins, populated by forms belonging to the ancient stocks which characterize the biota of present day Baikal. As we shall see later, the small lakes and ponds now found on the shores of Baikal contain common

Siberian species, and, with a single exception, none of the species that are peculiar to Baikal.

During the intervening Pleistocene, the Baikal Mountains flanking the lake on the west and the Vitim Plateau which rises above the northern third of the east shore developed glaciers. The southeast half of the Baikalian coast line was not approached by any glaciation, except for a tongue that reached from the Sayan Mountains toward the southern basin (Flint and Dorsey, 1945). Although the lake was apparently not covered by glacial ice, the lower temperatures undoubtedly had a profound effect upon its biota. Martinson (1940) found that many species of marine and brackish water affinities which had lived in the lake during the earlier part of the Cenozoic are now extinct.

It might be well to summarize a few facts which the reader should bear in mind while reading the following section on speciation. The south basin of the present Lake Baikal has held water continuously since the early Cenozoic or end of the Cretaceous. The trough in which the lake lies has been the site of considerable crustal movement, so that the lake has undoubtedly passed through a long and complex series of configurations. The lake in its present form is probably deeper than it has ever been before. The water down to the greatest depth sampled is well oxygenated, so that under present conditions aerobic organisms are not excluded from any part of the lake by a lack of oxygen. The effect of Pleistocene glaciation on the distribution of life in the lake is unknown. The relevance of the rest of the material presented should become apparent during the discussion of speciation.

COMPOSITION OF THE BAIKALIAN FAUNA

A scrutiny of Table 1, which summarizes our knowledge of the fauna of Lake Baikal, will reveal several unique aspects. Immediately apparent is the high degree of endemism and the small number of groups dominated by non-endemic species. The protozoa, rotifers, and diatoms (the latter group having 310 endemic and 369 non-endemic species), the three chief groups represented primarily by non-endemic species, have many species which are widely distributed throughout the freshwaters of the world, and are characterized by the ease with which they are passively dispersed. The non-endemic fish all belong to species with wide distributions, and undoubtedly have actively invaded Baikal within relatively recent times, bringing parasites with them.

The absence from the faunal list of many freshwater animals will be readily noted by anyone familiar with the biological communities of lakes. There are no amphibious vertebrates, and the Trichoptera are the only amphibious insects. Although no rhizopods, hydrarachnids, or cladocerans are recorded from Baikal proper, species of these and of chironomids, all typical of that part of the Palaearctic, are abundant in the small lakes which empty into Baikal, and in the ponds and

TABLE 1

Endemism of the Baikalian Fauna

(Based on Table 1 of Vereščagin, 1940)

GROUP	TOTAL NO. ENDEMIC FORMS	TOTAL NO. NON-ENDEMIC FORMS	PER CENT OF ENDEMISM
Protozoa	80	130	38%
Porifera	6	1	86%
Coelenterata	0	1	0%
Platyhelminthes	(89)	(7)	93%
Turbellaria	(86)	(0)	100%
Rhabdocoela	7	0	100%
Alloeocoela	1	0	100%
Triclada	78	0	100%
Trematoda	3	3	50%
Cestoda	0	4	0%
Nematodes (?)*	3	2	60%
Annelida	(59)	(4)	94%
Polychaeta	1	0	100%
Oligochaeta	53	4	93%
Hirudinea	5	0	100%
Rotifera	6	17	26%
Bryozoa	1	0	100%
Arthropoda	(377)	(7)	98%
Crustacea	(370)	(7)	98%
Copepoda	(38)	(7)	84%
Calanoida	0	2	0%
Harpacticoida	37	0	100%
Parasitic	1	5	16%
Ostracoda	36	0	100%
Isopoda	5	0	100%
Amiphipoda	291	0	100%
Insecta			
Tricoptera	7	0	100%
Mollusca	(98)	(1)	99%
Gastropoda	91	1	99%
Pelecypoda	7	0	100%
Vertebrata	(30)	(7)	81%
Fish	29	7	81%
Mammalia	1	0	100%

* The nematodes are queried because their number is astonishingly low.

swamps associated with the deltas of the larger rivers.

The following section deals in more detail with some elements of the fauna which contribute most to our knowledge of the origin of the biota and its evolution.

Porifera

The sponge fauna is remarkable for the presence of the Lubomirskiidae, comprising the genera *Baicalospongia* Annandale, *Lubomirskia* W. Dybowski, *Baikalolepis* Makushok (1927), and *Swartschewia* Makushok. The only representatives of this family known outside of Lake Baikal is *Baicalospongia dzhegetajensis*, which Rezvoj (1927) described from Dzegetaj-Kul in the Uriankhai region (Tanna Tuva) to the west of the southern end of Baikal. Little is known about this small lake. Martinson (1940) found spicules in the deposits of an ancient Lake Baikal which are similar to those of the extra-Baikalian species. The primitive nature of *B. dzhegetajensis* is also indicated by its resemblance to *Lubomirskia*. Martinson (1940) considers that the Lubomirskiidae, together with the Caspian sponges of the genus *Metschnikovia* Grimm (family Gellidae) and the genus *Ochridospongia* Arndt of Lake Ochrid, represent a stock which split off from its marine ancestors (Renieridae?) independently of the widespread freshwater Spongillidae. This conclusion is apparently confirmed by the findings of Taliev (1940), whose serological studies indicate that *Baikalospongia* is more closely related to a Caspian sponge than to the Spongillidae.

There are also spongillids of the genera *Spongilla*, *Carterias*, and *Ephydatia* in Baikal.

Turbellaria

Although Vereščagin lists 86 species of Turbellaria from Baikal, this number should be considered only an approximation, since 78 of these are triclads described in a superficial, highly unsatisfactory way by Korotneff in 1912.

Over half of Korotneff's species are assigned to the genus *Sorocelis*, which had been established by Grube in 1872 for a many-eyed triclad from Baikal and given the specific name *nigrofasciata*. Subsequently numerous species of many-eyed triclads from Baikal, and the rest of Asia as well, were assigned to this genus, largely because it had never been properly defined. In 1930 Kenk limited the genus to many-eyed species of the family Dendrocoelidae, and assigned multiple-eyed Planaridae to *Polycelis* Ehrenberg 1831. Kenk lists the genus *Seidlia*, which Sabussow proposed in his 1911 paper on Baikalian triclads, as a synonym of *Polycelis* Ehrenberg, so that there are species of both *Sorocelis* and *Polycelis* in Baikal. Kenk found it impossible to assign the 38 species which Korotneff ascribed to *Sorocelis* to either genus, because their anatomy is unknown. Even the 19 species which Sabussow, usually a careful worker, called *Sorocelis* in 1911 cannot be properly placed, as he failed to describe the critical anatomical features. The status of each of the 25 species of *Planaria* which Korotneff claims from Baikal is dubious for similar reasons.

In addition to these there are about a dozen species of triclads in Baikal which are remarkable in their possession of one to many suckers. Korotneff classified these in six genera, four of his own creation, and believed that they constituted an endemic family. Until more is known of the anatomy of these animals, their position in relation to other Probursalia cannot be determined. Several names have been given to this family. Korotneff first called it Cotylifera in 1908, but in 1912 substituted Cotylidae. However, this is invalid, as it is not named after a genus in the family, and Van Graff while monographing the Turbellaria proposed the name Procotylidae after *Procotylus* Korotneff 1912. To add to the confusion, Vereščagin (1940) called the family Rimacephalidae. This name is based on *Rimacephalus*, which Korotneff introduced in 1901, on the ground that its previous name was occupied, for a species that Grube in 1872 had named *Dicotylus pulvinar*. But this substitution is unwarranted because, as Berg (1928) pointed out, the prior name cited is really *Dicotyles* Cuvier, and not *Dicotylus*. Therefore, neither *Rimacephalus* nor Rimacephalidae is valid, and Procotylidae Van Graff is the correct name for this ill-defined group of sucker-bearing Baikalian triclads.

The genus *Sorocelis*, the only well-defined one to which any of the Baikal triclads can be assigned, is primarily an Asiatic genus, although it has been found in New Guinea and North America (Hyman, 1939). The American form is known to occur only in the ancient Ozark Mountains, living in caves and in springs associated with caves.

The single Baikalian representative of the Alloeocoela, *Baikalarctia gula* Friedmann 1926, reaches a length of 40 mm. and is about one-half as wide. This species is sufficiently distinct to be separated into its own family, the Baikalarctiidae (Bresslau, 1933).

Six of the rhabdocoels belong to *Baikalellia*, a genus erected by Nasonov in 1930 for these and two extra-Baikalian species. This genus is placed in the family Graffillidae. The species in Lake Baikal are associated with littoral vegetation, having never been taken below 30 m. They undoubtedly constitute a species flock. The position of the seventh Baikalian rhabdocoel has not been settled. Although Rubtzoff assigned it to the polycystid genus *Acrorhynchus*, Nasonov (1930b) indicates that from the published description it cannot be assigned to any genus of Polycystidae. Settlement of its position awaits a more complete description.

Annelida

A sabellid polychaete *Manajunkia baicalensis* (Nusbaum) lives in Lake Baikal (Fig. 3, *13*). Species of this genus have been found in widely separated points in Eurasia and North America, inhabiting fresh and brackish waters as well as the littoral zone of the sea.

Roughly half of the endemic oligochaetes are distributed among twelve genera of the family Lumbriculidae. *Lamprodrilus* Michaelson, probably the most primitive genus of the family, has sixteen species. Eleven are known only from Baikal. Two other Baikalian species have also been found in old European lakes. *L. pygmaeus* occurs outside of Baikal in Lake Ochrid in Macedona, and *L. isoporus* in Lakes Ladoga and Onega in Russia. Three species of *Lamprodrilus* do not occur in Baikal. *L. tolli* has been found in northern Siberia and on the New Siberian Islands, *L. michaelsoni* is a Balkan form, and the third species, *L. mrazeki*, has been discovered in Bohemia (Svetlov, 1936). One of the smaller endemic genera, *Agriodrilus*, deserves mention. This monotypic genus differs from all other oligochaetes in the excessive development of mesenchymatous tissue, which restricts the coelom in the anterior and middle regions of the body. Michaelson (1926) is of the opinion that *Agriodrilus* illustrates the way in which the leech morphology developed from that characteristic of oligochaetes.

Mollusca

About 90 species of molluscs have been described from Lake Baikal, all but 15 of which are snails, both prosobranchiate and pulmonate. One pulmonate genus *Physa* has a single Baikalian species, while *Limnaea*, *Planorbis*, and *Ancylus* have 2, 5, and 5 species, respectively. One nonendemic prosobranchiate genus *Valvata* has 7 Baikalian species, and another, *Bulimus*, is uniquely represented.

Choanomphalus, with 15 species, is the only endemic pulmonate genus (Fig. 2, *12*, *13*), while there are four prosobranchiate genera, *Benedictia*, *Kobeltocochlea*, *Baicalia*, and *Liobaicalia*. The architecture of the shells of *Benedictia* and *Kobeltocochlea* is very similar, but they can be concisely differentiated on the basis of the radular structure (Fig. 2, *1–4*). The lateral and marginal plates of *Benedictia* are without teeth while those of *Kobeltocochlea* are toothed. Furthermore, the middle plate in *Kobeltocochlea* has a mesocone which is never found in *Benedictia*. Lindholm (1926) has separated the three species of the latter genus into three subgenera, employing the differences in the middle plates. Lindholm considered *B. fragilis* (the most typical species) most primitive because of the lack of marginal teeth on the middle plates. The degree of development of the toothed margins differentiates the subgenera *Dalainoria* and *Baicalocochlea*. The radula of *Kobeltocochlea* with its strongly-toothed margins is regarded as the terminal member of this evolutionary series. Lindholm, who was the foremost recent student of the Baikalian molluscs, stated (1926) that the species in these two genera exhibit no affinity with any other living snails and must be considered to constitute the family Benedictiidae. Rammelmeyer (1940) assigned a Cretaceous snail *andreae* from the Vitim region to the east of Baikal, which he had originally described as *Paludina*, to *Benedictia*. If he is correct, this agrees with Lindholm's interpretation that *Benedictia* is the more primitive. Until 1929 the Benedictiidae was considered to be restricted to Lake Baikal. In that year Lindholm received for identification five dried-up snails from Lake Kosogol, which lies 230 km. west of the southern end of Lake Baikal. As these were the first snails from Kosogol to come before the eyes of a biologist, they were of considerable interest. Four proved to be of a local race of the widely distributed *Limnaea* (*Radix*) *auricularia*, but the fifth was clearly a benedictiid. Although generic determination of such a poorly preserved specimen was difficult, Lindholm concluded that it represented a new species, *Kobeltocochlea michnoi*. How this snail came to be in Kosogol is not clear. Kosogol drains into one of the westernmost tributaries of the Selenga River, and it might have penetrated from Lake Baikal into the Selenga and thence upstream about 1000 km. into Kosogol. One species of fish, *Thymallus arcticus baicalensis*, is common to the two lakes. This may also have entered through the Selenga. As yet the fauna of this river is completely unknown.

The 32 species of *Baicalia* make it by far the largest of the endemic genera. Unlike *Benedictia*, these species have radulae of little taxonomic importance, whereas a satisfactory classification has been based on the structure of the shell. Lindholm recognized 11 subgenera. Representatives of six of these are depicted in Fig. 2, *5–10*, by photographs taken from the beautiful lithographs which accompanied Dybowski's 1875 paper on the gastropods of Lake Baikal. The nomenclature is based upon that given by Lindholm (1924). A species with an evolute shell has been placed in the monotypic genus *Liobaicalia* (Fig. 2, *11*), but it is clearly a member of the *Baicalia* species flock.

Cretaceous shells from Transbaikalia, i.e., the region to the east of the lake, have been assigned by Rammelmeyer (1940) to *Baicalia.* One very badly preserved shell was compared with *B. ciliata*; another resembled *B. florii*. Several shells previously described by Reiss as *Cerithium gerassimori* were placed by Rammelmeyer in *Baicalia*.

The exceedingly fine dentition on the radulae of *Baicalia* is unlike that of any of the families to which *Baicalia* appears similar on the basis of conchological characters: Melaniidae (tropical Asia), Micromelaniidae (Caspian Sea), Pleuroceridae (American), Hydrobiidae (=Amnicolidae=Paludestrinidae). Lindholm (1926) concluded that *Baicalia* and *Liobaicalia* cannot be assigned to any prosobranch family and must be considered to constitute the family Baicaliidae. Some malacologists have assigned these four prosobranchiate genera to that large family variously called Hydrobiidae, Ammicolidae, Paludestrinidae. (In 1924 Annandale pointed out that this family of freshwater and estuarine snails cannot be clearly separated from the marine Rissoidae on either morphological or ecological grounds.) Thiele (1928), in a revision of the taxonomy of this assemblage of freshwater snails, further subdivided them into the families Hydrobiidae and Micromelaniidae. He classified *Benedictia* and *Kobeltocochlea* as a tribe Benedictieae of the typical subfamily of Hydrobiidae, disagreeing with Lindholm's conclusion that the radulae in these two genera are widely different from those of certain hybrobiids. Furthermore, he believed that *Benedictia* is the more divergent genus, as *Kobeltocochlea* shows the strongest resemblance to other hydrobiids. *Baicalia* and *Liobaicalia* are placed in the typical subfamily of the Micromelaniidae, because of the great similarity of shell and dentition. Thiele does not cite Lindholm's (1926) views.

The pelecypod genera *Sphaerium* and *Pisidium* have five and nine Baikalian species, respectively.

Crustacea, Isopoda

All of the isopods of Lake Baikal belong to the genus *Asellus*. Birstein's recent study (1939) has confirmed the presence of five species. Four clearly belong to the subgenus *Baikaloasellus*, which Stammer erected in 1932 for the only two Baikalian species well characterized at the time. The fifth species, *A. dybowskii* Semenkewitsch, provisionally placed by Stammer in *Baikaloasellus*, is separated by Birstein into a new subgenus *Mesoasellus*, together with cave-dwelling species from Japan and California. *Mesoasellus* and *Asellus* sensu strictu resemble each other in the possession of several primitive morphological features. *Baikaloasellus* is closer to *Mesoasellus* than it is to any of the other three subgenera. Birstein believes that the species of *Baikaloasellus* arose in the lake from a representative of *Mesoasellus*.

Crustacea, Amphipoda

The amphipods are the most remarkable element of the Baikalian fauna, for there are 291 species assigned to 30 genera. Some of the structural diversity to be found among these gammarids is shown in Fig. 3. Only one species is non-endemic, and only three of the genera have extra-Baikalian representatives. Presentation of a possible mechanism by which this large number of species could have arisen comprises one of the main theses of this paper.

An equally fascinating aspect of the problem presented by this group is the determination of its affinities. In 1928 three genera (*Axelboeckia, Carinogammarus, Echinogammarus*) were considered to be non-endemic in addition to the three now known to be so. Stebbing in 1906 grouped a Caspian amphipod with two Baikalian species into a genus *Axelboeckia*. Schellenberg (1940) believed the two groups unrelated and created *Boeckaxelia* for the Baikalian forms, since the type of *Axelboeckia* lives in the Caspian Sea. Schellenberg (1937) indicated that the extra-Baikalian amphipods classified as *Carinogammarus* had been incorrectly assigned. The genus is endemic to Baikal. In the same paper he presented evidence that the non-Baikalian species of *Echinogammarus* are unrelated to the Baikalian forms assigned to this genus. As the type species does not occur in Baikal, the use of this generic name for species in the lake is erroneous. However, as no satisfactory name has been proposed, this genus will be referred to as "*Echinogammarus*" in this paper.

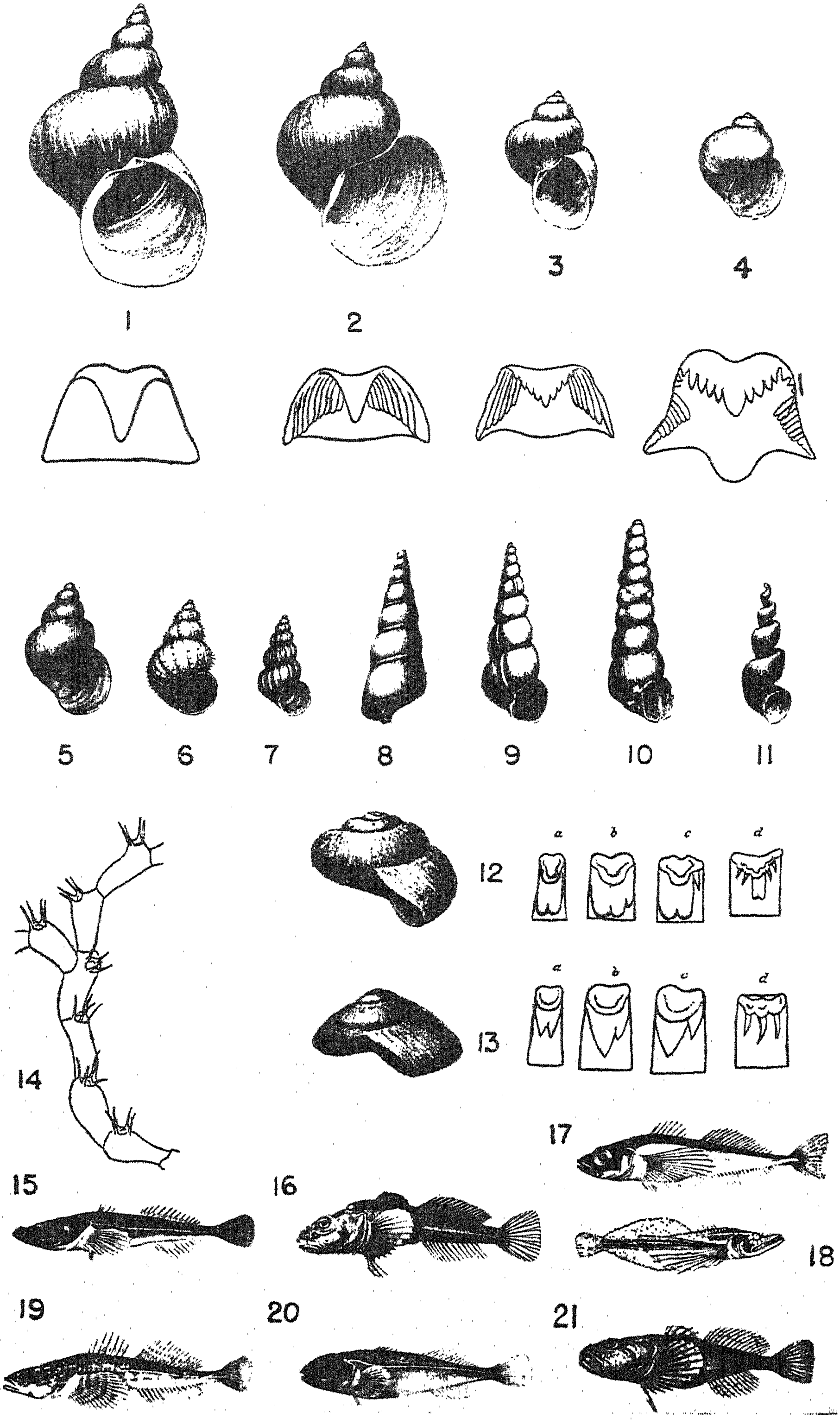
The three apparently authentic non-endemic genera (*Gammaracanthus*, *Pallasea*, and *Brandtia*) differ widely in their distribution. *Gammaracanthus loricatus* occurs in its typical form along the shores of the Arctic Ocean. A subspecies *lacustris* has been found in many lakes of the Baltic region of Europe and in at least one of the Siberian rivers draining into the Arctic Ocean, the Yenesei (Pirozhnikov, 1931). The Baikalian population is accorded subspecific rank as *G. l. baicalensis*. A Caspian counterpart is *G. l. caspica*. *Pallasea*, unlike *Gammaracanthus*, has many (at least 12) endemic species in Lake Baikal. *Pallasea quadrispinosus* occurs in the Baltic region, and in a small lake, Nalimje, on the western border of the Yenesei watershed (Pirozhnikov, 1933). Neither this species nor *P. laevis*, known from the freshwaters of Novaya Zemblya, occurs in Lake Baikal. Although the amphipod fauna at the mouths of the large rivers emptying into the Arctic Ocean has been extensively studied, neither these nor any other species of *Pallasea* have been found (Berg, 1935). There is no evidence that this species is of marine origin. *Brandtia* has an extra-Baikalian distribution quite different from that of either of the preceding two genera. At least three species of *Brandtia* have been described which are restricted to Lake Baikal. In addition, *Brandtia fasciata* is not only a common littoral form in the lake but also occurs in the small ponds draining into Baikal and throughout the Yenesei System, (Gurjanova, 1929), even in Nalimje Lake (Pirozhnikov, 1933). In the Yenesei delta the *Brandtia* population was sufficiently different from *B. fasciata* to be specifically distinguished as *B. fasciatoides* Gurj. As *Brandtia* has not been found outside of the Yenesei System, it is probable that this genus arose in Baikal and spread to other parts of the drainage system.

On the basis of this evidence, *Pallasea* appears to be the only one of the non-endemic genera which might represent one of the ancient amphipod stocks from which the multiplicity of Baikalian species arose. However, *Pallasea* shows less serological affinity with any of the 12 large endemic Baikalian genera than it does with *Pallasea quadrispinosa* from Lake Ladoga. This makes it rather unlikely that *Pallasea* is a relatively unmodified descendent of a stock from which any endemic genera have differentiated.

As the non-endemic genera do not appear to represent any of the original amphipod stocks, more tenuous evidence of the affinities of the endemic genera must be considered. Bazikalova

FIG. 2. REPRESENTATIVES OF THE BAIKALIAN FAUNA, PART 1

1–4, Shell and median radular plate (much enlarged), of
  1, *Benedictia (Benedictia) fragilis* Dyb., shell height 49 mm.,
  2, *Benedictia (Dalainoria) limaeoides* (Schrenck), height 38 mm.,
  3, *Benedictia (Baicalocochlea) baicalensis* (Gerst.), height 23 mm.,
  4, *Kobeltocochlea martensiana* (Dyb.), height 18 mm.
5, *Baicalia (Eubaicalia) angarensis* Gerst., height 7.5 mm.
6, *Baicalia (Dybowskiola) ciliata* Dyb., height 11 mm.
7, *Baicalia (Maackia) costata* Dyb., height 7 mm.
8, *Baicalia (Baicalia) carinata* Dyb., height 16.5 mm.
9, *Baicalia (Godlewskia) turriformis* Dyb., height 16 mm.
10, *Baicalia (Gerstfeldtia) Godlewskii* Dyb., height 19 mm.
11, *Liobaicalia stiedae* (Dyb.), height 9 mm.
12–13, Shell and radular plates (much enlarged), a = median plate, etc., of
  12, *Choanomphalus maacki* Gerst., shell width 6 mm.,
  13, *Choanomphalus valvatoides* Dyb., shell width 3 mm.
14, *Hislopia placoides* (Kor.) Branch of a colony. (enlarged ca. 10×)
15, *Limnocottus godlewskii* (Dyb.) length 190 mm.
16, *Limnocottus megalops* (Gratz.) length 160 mm. (male)
17, *Cottocomephorus grewingki* (Dyb.) length 175 mm. (female)
18, *Comephorus baicalensis* (Pallas) length 190 mm. (male)
19, *Batrachocottus multiradiatus* Berg length 150 mm.
20, *Batrachocottus nikolskii* (Berg) length 200 mm. (male)
21, *Batrachocottus baicalensis* (Dyb.) length 190 mm. (male)
(1–13 from Dybowski, 1875; 14 from Abricossoff, 1924; 15–21 from Berg, 1916. Retouched.)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(1940) is of the opinion that the resemblances between four endemic Baikalian genera (*Brandtia*, *Hyallelopsis*, *Crypturopus*, and *Micruropus*) and four endemic Caspian genera are not the result of convergent modifications to meet similar ecological requirements but indicate genetic affinity. If this interpretation is correct, there were at least four original stocks in the primordial Baikal. Taliev's (1940) serological examinations were not designed to test this conclusion, although they gave no indication of close affinity with any Caspian genera.

The number of original amphipod stocks in Baikal undoubtedly falls between 4 and 29. Certainly the larger figure, the total number of genera at the present time, is too high. Six genera are monotypic and probably represent divergent members of larger stocks. For example, *Gammaracanthus insularis* is almost certainly derived from the *Hyallelopsis* stock (Bazikalova, 1935). Furthermore, serological comparisons indicate that several of the large genera may have a common origin. In Taliev's tests, representatives of *Pallasea*, "*Echinogammarus*," and *Acanthogammarus*, three of the largest genera, were compared to each other and to *Brandtia*, *Crypturopus*, *Boeckaxelia*, *Carinurus*, *Parapallasea*, *Abyssogammarus*, *Carjajewia*, *Brachyuropus*, *Spinacanthus*, and *Odontogammarus*. *Pallasea* gave no positive reaction with any of these genera. "*Echinogammarus*" gave a strong positive reaction with *Abyssogammarus*, somewhat less but still strong with *Odontogammarus*. *Acanthogammarus* had a strong serological affinity with *Brachyuropus*, slightly less with *Boeckaxelia*, *Carinurus*, and *Spinacanthus*. Assuming that each of these groups have evolved from a single stock, the maximum number of original populations now required is 18. It is of interest that not one of the four genera which Bazikalova considered little modified from the ancestral stocks showed any unequivocal serological affinity with other endemic genera.

Despite the wealth of bottom-living species, only one has left the bottom for the open water community. This species, *Macrohectopus branickii*, is common in the plankton. In the lakes of North India *Gammarus* (*R.*) *pulex* is a common benthic form, which has become pelagic in a single lake, one which lacks fish (Uéno, 1934).

Bazikalova has studied the breeding periods of five gammarids, according to the *Zoological Record* but the paper (1941) itself was unavailable.

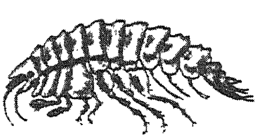
Crustacea, Ostracoda

These small bottom-living crustaceans have been recently studied by Bronstein (1936), who finds that the 36 Baikalian forms known belong to three genera, *Candona* and *Pseudocandona* (Cypridae) and *Cytherissa* (Cytheridae).

There are eight endemic species of *Pseudocandona* in Baikal and only 3 species found elsewhere. One of these extra-Baikalian species is known from subterranean basins in Switzerland (*P. zschokki*); the second, living in small open basins, is widely scattered throughout Europe but is rarely encountered (*P. insculpta*); the third has been found in Lake Windemere (England) and Lake Ochrid (Jugoslavia). It is very likely that two other cavernicolous species also belong to this genus, but this assignment is not definite, as no males have been found. The Baikalian species of *Pseudocandona* possess several characters which indicate an organization not only more primitive than that of non-Baikalian species, but also more primitive than is found in any other of the non-swimming genera of its subfamily. (Heavy shell, trapezoidal form, undivided penultimate joint of second antennae in male and lack of sexual setae thereon, undivided penultimate joint of sensory legs, and

FIG. 3. REPRESENTATIVES OF THE BAIKALIAN FAUNA, PART 2

1, *Hyalellopsis grisea* Dor., length 23 mm. Sublittoral, Southern Province.
2, *Hyalellopsis clavata* Dor., length 11 mm. Sublittoral, Littoral.
3, *Boeckaxelia carpenteria elegans* (Dor.), length 35 mm. Sublittoral, Small Sea Province.
4, *Boeckaxelia potanini* (Dor.), length 34 mm. Sublittoral, Selenga Province.
5, Same, in dorsal view.
6, *Pallasea brandtii flaviceps* Dor., length 33 mm. Sublittoral, Selenga Province.
7, *Pallasea bicornis* Dor., length 43 mm. Sublittoral, Small Sea Province.
8, *Brachyuropus nassonowi* Dor., length 60 mm. Transitional, Southern.
9, *Acanthogammarus flavus rodionowi* Dor., length 20 mm. Sublittoral, Southern.
10, *Acanthogammarus godlewskii brevispinis* Dor., length 55 mm. Sublittoral, Selenga Province.
11, "*Echinogammarus*" *melanochlorus* Dor., length 45 mm. Littoral.
12, "*Echinogammarus*" *virgatus* Dor., length 94 mm. Transitional, Northern.
13, *Manajunkia baicalensis* (Nusbaum), length 5 mm. chiefly Sublittoral.
(1–3, 7, 11, 12, from Dorogostaisky, 1930; 4–6, 8–10 from Dorogostaisky, 1922; 13 from Nusbaum, 1901. Retouched.)



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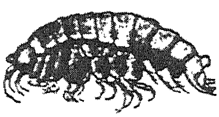

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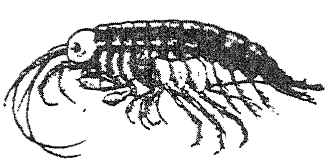

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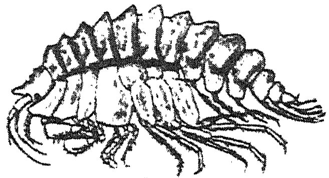

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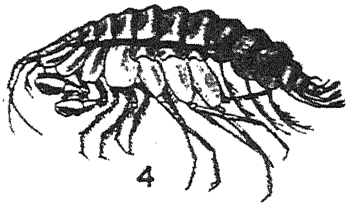

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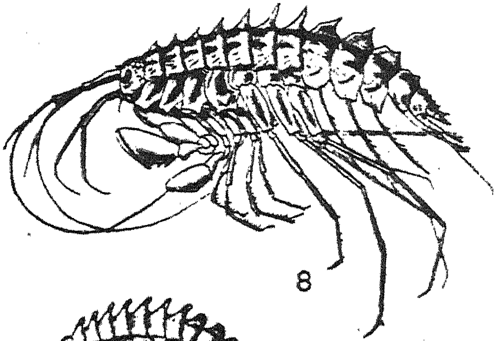

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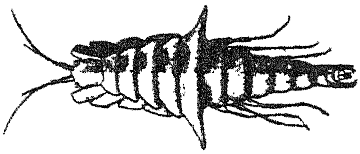

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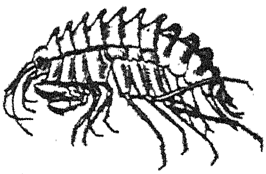

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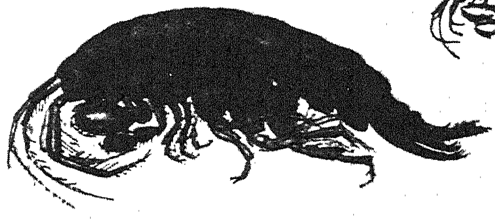

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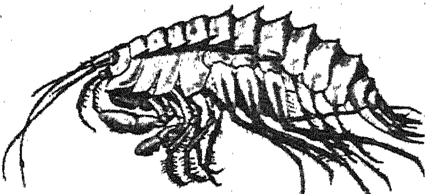

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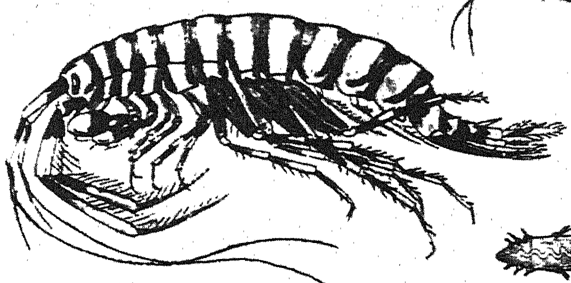

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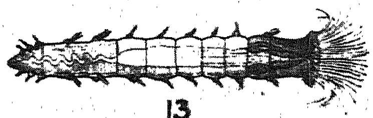

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absence or feeble differentiation of genital appendages in female.)

The ten species of Baikalian *Candona* occupy a rather isolated position with regard to many non-Baikalian forms, according to Bronstein. They possess not only several primitive characters (trapezoidal shape, reticular sculpture of shell, undivided penultimate joint of sensory legs, female showing feeble development of genital appendages), but three species also have claws on the first antennae, a condition unknown in any other member of the family Cypridae. The ostracod which Bronstein identified as *Candona inequivalvis* var. *baicalensis* is the only Baikalian form which resembles a non-Baikalian species, and is presumably a geographical subspecies.

Eighteen species and subspecies of *Cytherissa* have been described from Baikal, whereas only one species is known elsewhere, this occurring in large freshwater lakes in Eurasia and Japan. The latter species, *C. lacustris*, is parthenogenetic, whereas all of the Baikal species are amphigonic, undoubtedly the more primitive condition. Thus Bronstein believes that, with the single exception noted above, the species group of each genus has developed in the lake, each represenring the derivatives of ancient stock which have been long isolated.

Crustacea, Copepoda

The only species flock among the copepods is to be found among the bottom-living harpacticoids. Five closely related species of *Moraria* were described by Borutzky (1931), who considered that they constitute the subgenus *Baikalomoraria*. Five other canthocamptids also were described. The harpacticid *Harpacticella inopinata* Sars has an interesting extra-Baikalian distribution which will be subsequently discussed. No reference to the remainder of the 37 harpacticoid species listed by Vereščagin could be found.

Among the several planktonic calanoids the temorid *Epischura baicalensis* Sars is noteworthy. Its ecology and distribution will receive comment later.

Teleosts

The fish fauna of Baikal presents great interest for the student of speciation, inasmuch as it includes a group of peculiar cottoid fish in addition to representatives of many widespread Palaearctic genera. These endemic cottoids claim first attention. Eighteen species have been assigned to ten genera (Berg, 1928; Taliev, 1935, 1946). Two species clearly belong to the holoarctic *Cottus*, *C. kneri* Dyb. and *C. kessleri* Dyb. The manner of relating the other nine genera is disputed. Berg has grouped them into two endemic families, the Cottocomephoridae and Comephoridae. The latter would contain a single genus *Comephorus*, with its two pelagic species *C. baicalensis* (Fig. 2, *18*) and *C. dybowskii*. The question of the origin of two pelagic species in the lake is of considerable importance, but its consideration will be more appropriate in a subsequent section. This genus, although undoubtedly related to the former group, differs greatly from them. This divergence in structure is correlated with the pelagic habit of *Comephorus*, for one species of cottocomephorid, *Cottocomephorus grewingki* (Dyb.) (Fig. 2, *17*), which has also left the bottom for the open waters, exhibits similar modifications. Berg (1940) separates this latter species, as the sole member of the subfamily Cottocomephorini, from the six bottom-dwelling genera (*Abyssocottus*, *Cottinella*, *Limnocottus*, *Batrachocottus*, *Asprocottus*, *Procottus*) which constitute the Abyssocottini. The recently described (Taliev, 1946) *Mesocottus* should be included in the latter subfamily.

Vereščagin (1940), following Taliev, has believed that these Baikal endemics, with the exception of *Cottus kessleri* and *C. kneri*, should be referred to a single family. Taliev's serological studies (1940) provided some evidence of relationships which are not accounted for in Berg's classification. The genera of Abyssocottini, except for *Cottinella* and *Mesocottus*, which were not examined, fall into two groups. *Procottus* and *Batrachocottus* (Fig. 2, *19 21*) comprise one; *Limnocottus* (Fig. 2, *15*, *16*), *Asprocottus*, and *Abyssocottus* the other. The lack of serological affinity between the two pelagic genera is of considerable interest, *Cottocomephorus* being similar to the first group of bottom forms and *Comephorus* to the second. This concept of relationships based upon serological affinities received confirmation in a subsequent osteological comparison using x-ray photographs (Taliev, 1938, reported in Taliev, 1946), and was further strengthened by Taliev's (1946) discovery of a single specimen of a new bottom-living Baikalian cottoid which exhibits structural similarities to both *Procottus* and *Cottocomephorus*. A new genus *Metacottus* was formed for this specimen.

Turning to the non-endemic fish of Baikal, we find twelve palaearctic species represented by populations which are little different from those found in other portions of their range. This group includes *Perca fluviatilis* L., *Esox lucius*, two cobitids, 5 cyprinids, 3 salmonids, the gadid *Lota lota* (L.), and *Acipenser bari*. The Baikalian populations of two salmonids are sufficiently distinct to be called geographical subspecies, namely, *Salvelinus alpinus erythinus* (Georgi) and *Coregonus autumnalis migratorius* (Georgi). *Coregonus autumnalis migratorius* is serologically as well as morphologically similar to *Coregonus autumnalis* (Pallas) from the Yenesei River (Taliev, 1940).

Mammalia

The Baikal seal, *Phoca sibirica* Gmelin, is the only mammal living in the lake. Recent serological studies (Taliev, 1940) have confirmed the relation of the Baikal seal to the seal of the Glacial Arctic Sea *Phoca hispida* rather than to that of either Lake Ladoga or the Caspian Sea.

Community Ecology

The associations and the dominant organisms of the benthic communities of Lake Baikal are unique among fresh waters, and even the pelagic community exhibits peculiarities. Diatoms appear to be the most important of the planktonic producers; and copepods, especially *Epischura baikalensis*, and the planktonic amphipod, *Macrohectopus branickii*, are the chief primary consumers of the open waters. Both of these inhabit the open waters from the surface to an undetermined depth below 300 m. The latter, although it has but recently become pelagic, performs a marked diurnal vertical migration (Zachvatkin, 1932). Both species of *Comephorus* feed primarily upon *Macrohectopus* (Vereščagin, 1926). Seals feed on *Comephorus* and other pelagic fish. As most of the littoral vascular plants are restricted to the few calm stretches of the coast, the dominant producers of the littoral benthic communities are algae, especially *Drapanaldia*. Green algae are rare below five meters, although bottom diatoms are found even at depths of 200–300 meters. The bacteria extend to the greatest depths. Benthic consumers in the deeper waters must be ooze-browsers (cf. Lindeman, 1941) deriving their energy from the organic material falling from the open water community in the form of dead phytoplankton and zooplankton and feces. A large part of this organic material is probably metabolized by the bacteria in the ooze before it is ingested by the larger consumers. The gammarids are clearly the dominant benthic consumers, but the polychaete *Manajunkia baicalensis* and molluscs may be locally important (Vereščagin, 1940). The bottom-living cottocomphorids probably feed upon the above-mentioned invertebrates, but no stomach analyses are available.

ORIGIN OF THE BAIKALIAN FAUNA

It is evident from the foregoing discussion that the major part of the Baikalian fauna has no affinity with the organisms which constitute the freshwater fauna of Eurasia at the present time. Any conclusions about the affinities of the Baikalian fauna must be based upon a consideration of the extra-Baikal distribution of close relatives of certain Baikalian groups. Vereščagin has interpreted these distribution patterns to mean that a large part of the fauna, including the gammarids and cottoids, has had its origin from the sea, as an introduction separate from any others which have given rise to the freshwater fauna elsewhere. He has also believed that a certain faunal element represents an archaic freshwater fauna preserved in Baikal but supplanted in most other freshwaters. The most recent statement of his views appeared in 1940. Berg (1935) has taken exception to Vereščagin's hypothesis of marine origin, and has cogently expressed his reasons for believing that the Baikalian stocks are, with the two exceptions noted below, relicts of an ancient freshwater fauna. Both have agreed that two Baikal populations have been derived from the sea. In our discussion of the non-endemic genera of amphipods it was evident that *Gammaracanthus* is the only genus which also occurs in the sea. The population in Lake Baikal has diverged only to the extent of a subspecies. This indicates that it has probably been in the lake for a much shorter time than any of the other gammarid populations. The Baikal seal also is only subspecifically distinct from the typical form of the Arctic Ocean. These two animals, as Berg has emphasized, are the only ones with close marine affinities. There is every indication that they have entered Baikal at a relatively recent time, probably during the marine transgression associated with the glaciation of Siberia. Each was probably introduced from the Yenesei System.

The distribution of the closest relatives of the many Baikalian endemics indicates that they are the relicts of an ancient fauna once widely distributed throughout the freshwaters of Eurasia. Both

Berg and Vereščagin have concurred in this interpretation. These animals constitute what Vereščagin has labelled the "Continental" as opposed to the "Marine" element. A few previously noted groups serve to exemplify this type of distribution. The copepod genus *Epischura* is represented in Baikal by a single species, *E. baicalensis*, which also occurs in a lake on the Kamchatka peninsula. The only other Asiatic species (*E. chankensis*) lives in a Chinese lake. The three other species of the genus live in North American lakes (Garber, 1941). The isopod genus *Mesoasellus*, and *Pseudocandona* among the ostracods, are represented outside of Baikal only by scattered species, many living in caves and subterranean waters of two continents. The distribution of *Sorocelis* even in Asia is discontinuous, and aside from Baikal, it does not occur in Siberia. The presence of a species in a cave in the Ozark Mountains of North America has been noted above. The oligochaetes of the genus *Lamprodrilus* are undoubtedly the most primitive living members of the Lumbriculidae. *Valvata* belongs in this group.

Some paleontological discoveries lend strength to this interpretation. The most pertinent of these, if correct, is that *Benedictia*, now restricted to Baikal, is common in Jurassic freshwater deposits of Transbaikalia (Rammelmeyer, 1940).

A large part of the fauna is composed of stocks which occur in marine or brackish water, or both, as well as in fresh water. The significance of this distribution pattern is controversial. Vereščagin has grouped these stocks with the two populations of undoubted marine origin, calling them the "Marine Element" of the Baikalian fauna. Included are the cottoids, gammarids, *Baicalia*, *Manajunkia*, *Hislopia* (a gymnolaematous bryozoan), and *Harpacticella*, as well as many ciliates and diatoms which will not be discussed, since they are poor material for zoogeographic studies.

The only evidence which Vereščagin has cited (1940) to support his contention that the Baikalian cottoids had their origin directly from marine ancestors is that the postcleithrum, absent or much reduced in the Cottocomphoridae and Comephoridae, is also wanting in *Myoxocephalus niger* Brehm, a marine species of the Far East.

Although Vereščagin has been of the opinion, backed by Bazikalova, that the Baikalian gammarids are of marine origin, there is no longer any direct evidence to support that view. The distribution of the non-endemic genera has been discussed above.

Vereščagin has assumed that *Baicalia* belongs to the Micromelaniidae, a family which occurs today in brackish water along the coast of India, in the Caspian and Aral Seas, in the brackish water of the Black Sea, in the depression of Lombardy, and in the old lakes Issyk-Kul (Siberia) and Erh Hai (Yunnan). Micromelaniids occur abundantly as fossils in deposits around the Black and Caspian Seas, while fossils referred to *Baicala* have been found in Circumbaikalia and Transbaikalia in both Mesozoic and Tertiary deposits. Vereščagin (1940) has considered this to be evidence of the marine origin of the micromelaniids, and hence of *Baicalia*.

Upon comparing the eight sabellids which had been placed in the genus *Manajunkia* by 1935, Zenkewitsch (1935) found that three species show a marked morphological similarity to *M. baicalensis*. These are *M. caspica* (brackish water), *M. aestuarina*, a European brackish water species, and *M. polaris*, a marine species which Zenkewitsch has discovered in great abundance in parts of the littoral region of the Murmansk coast. The type species *M. speciosa* from North American brackish and fresh waters is quite distinct from the above-mentioned group. Zenkewitsch believed that the marine *M. pacifica* (Commander Island) and *M. spongicola* (brackish Chilka Lake, India) should be placed in another genus, which he named *Fabriciella*, but did not define. He was of the opinion that *Manajunkia* had its origin in the freshwaters of Asia and has spread from there to brackish water and the sea.

Whereas most of the freshwater bryozoans of the present day belong to the order Phylactolaemata, the other order Gymnolaemata, largely marine, has a representative in Lake Baikal named *Hislopia placoides* (Fig. 1, *14*). However, species of *Hislopia* also occur in various freshwaters of China, Indochina, and India. *Hislopia* and four other genera are known from freshwater, two being represented in Lake Tanganyika.

Wesenberg-Lund (1896), Rousselet (1906), and Annandale (1911) have all expressed the opinion that these Gymnolaemata have invaded freshwater more recently than the Phylactolaemata. Two of the other genera living in freshwater are known to have marine representatives in the East Indian Ocean, namely, *Victorella* and *Arachnoidea* (Harmer, 1915). However, their presence in old bodies of freshwater, outside of areas of marine transgression in the central parts of Africa and

Asia, raises difficulties of such magnitude that it seems inadvisable to accept this opinion as final.

The harpacticid copepod *Harpacticella* is another genus with representatives in freshwater and in the East Indian Ocean. *Harpacticella inopinata* Sars is Baikalian. *H. paradoxa* (Brehm) lives in Erh Hai (Brehm, 1924, 1931) and *H. lacustris* Sewell is found in the Indian coastal lake, Chilka.

As previously mentioned, Martinson considers the Lubomirskiidae to have developed from the Renieridae independently of the Spongillidae, widely distributed throughout present freshwaters. He also has expressed the opinion that they have come from the sea more recently than the Spongillidae and therefore belong to Vereščagin's "Marine Element." If this is correct, the presence of a *Baicalospongia* in a snall lake in Uriankhai is difficult to explain.

Although Vereščagin has claimed that the family Graffillidae to which the rhabdocoel *Baikalellia* pertains is typically marine, Berg (1935) has shown that this is not justified by the evidence.

Acceptance of the interpretation espoused by Vereščagin that a large part of the Baikalian fauna has been derived from the sea independently of, and more recently than, that widely expanded in fresh waters necessitates the postulation of a geologically acceptable explanation of the introduction of these marine organisms into Lake Baikal. As there are no marine deposits in or near the Baikal basin of late Mesozoic or Cenozoic age the possibility of the lake's site having been occupied by an arm of the sea is excluded. The explanation advanced by Vereščagin is that a small marine basin somewhere in the vicinity of Baikal lost its connection with the Cretaceous sea and began to freshen with the inflow of land drainage. Some of the marine organisms trapped in such a basin would be unable to tolerate the decrease in salinity. Others could. Some of these more tolerant stocks eventually became completely adapted to the freshwater environment. These might then spread into connected fresh waters. Thus would Baikal have received its derived marine element. Derjavin (1924) has expressed the belief that this is the manner in which the greater proportion of the earth's freshwater organisms have accomplished the transition.

With acceptance of Berg's interpretation that the major Baikalian stocks are relicts of an ancient freshwater fauna, a consideration of its origin is unnecessary here.

THE MODE OF EVOLUTION OF LACUSTRINE SPECIES FLOCKS

Each person who has studied the taxonomy of one of the various species flocks in old lakes has concluded that the species group under consideration has evolved in the lake. Dorogostaisky (1923), studying the Baikalian fauna, and Moore (1903), studying those of Tanganyika and Nyasa, have independently expressed the opinion that intra-lacustrine geographical factors were involved in the evolution of the species flocks. However, Woltereck in 1931 advanced the hypothesis that the evolution of these lake swarms is entirely different from the geographical speciation evident in many terrestrial organisms. The essence of his hypothesis is that a population in an old lake might suddenly split into many subpopulations each adapted to a different ecological niche. He adduced no critical evidence in support of this hypothesis. Although some freshwater biologists have exhibited a tendency to accept this hypothesis, Mayr has so ably criticized this and other hypotheses of ecological speciation (1942, 1947) that no more need be said here. However, Mayr considered that, since Woltereck's hypothesis was invalid, species flocks could not evolve within a lake. This led him to postulate that these lacustrine species flocks originated through multiple introductions of closely related species. This might be accomplished in two ways. The first would be by a series of introductions of related populations from the various waters with which an ancient lake might have been continuous during the course of its long history. The second would be by the merger of a series of related populations which had hitherto enjoyed spatial isolation long enough for the development of specific distinctions.

It is now our task to examine this hypothesis of multiple colonization in the light of the extensive data which have been gathered concerning the species flocks in Baikal, as well as the suggestion that intra-lacustrine geographical factors are involved in species flock formation. Let us first consider the second type of multiple introduction. According to this, the species flocks of Baikal arose by amalgamation of a series of lakes each of which contained a number of endemic species. By this fusion these endemics were thrown together, forming species flocks. There is no direct evidence about the antecedent waters from which Baikal received its fauna. If Vereščagin's interpretation is correct, the possibility that there were two lakes must be considered, because the marine stocks may have been in one while the ancient freshwater stocks were in the other. If this was so, it is obvious that not even species pairs would be formed as it is unlikely that the same genera would be represented in each body of water. Berg's interpretation does not require more than one body of freshwater. Yet, to explain the origin of the largest species flock, that of "*Echinogammarus*," it must be assumed that there were at least 24 separate basins each of which had been isolated sufficiently long for its "*Echinogammarus*" population to have become specifically distinct. This is highly improbable.

The other type of multiple colonization requires that there have been a series of invasions of closely related species from adjacent waters during the history of Baikal. Invasions would be possible either by capture of the lake by different river systems or by the coalescence or connection of the larger lake with adjacent ponds and small lakes. The former seems a priori the more likely, since the cool waters of a large lake such as Baikal are more easily invaded by species adapted to life in rivers and streams than to life in small ponds, wherein the temperature is apt to be much higher during a part of the year.

There is direct evidence to indicate that continuity of Lake Baikal with waters supporting a different fauna has not been followed by an interpenetration of the two faunal groups. At the present time several lakes along the coast of Baikal drain directly into the larger lake through short rivers. The biota of these lakes is the same as that widely distributed in Siberian freshwaters. Furthermore, the biota of several shallow lagoons broadly connected with the open waters of Baikal itself is dominantly Siberian and not Baikalian. This is understandable when it is appreciated that each fauna is adapted to its own environment, and that invaders of the foreign environment must compete with their well-adapted ecological equivalents. The Siberian fauna, with a few exceptions, has not been able to compete successfully under the peculiar conditions to which the Baikalian fauna is so well adapted. The greater part of the Baikalian fauna adapted to cool waters has not been able to compete successfully along those small reaches of its shore characterized by high summer temperatures with the Siberian fauna adapted to a greater temperature fluctuation. The only Baikalian species which have been notably successful in competition with their Siberian equivalents are a few gammarids adapted to the littoral zone of the lake. In the very shallow waters fringing one of the large bays of Baikal, the Small Sea, the biota is dominantly Siberian; but one of the ubiquitous Siberian elements, *Gammarus* (*Rivulogammarus*) *pulex*, is missing. Its place is taken by several Baikalian gammarids, of which one is *Brandtia fasciata*. Furthermore, *Brandtia fasciata* has been able to invade the shallow lagoons and lakes opening into Baikal and even to spread into the Yenesei River System. The most reasonable explanation is that some of the numerous Baikalian species have become adapted to the same environment as *Gammarus pulex* and can successfully compete with it on its home territory.

The Baikalian fauna has been able to withstand invasion from adjacent waters for the greater part of its history. Martinson has found that throughout the Cenozoic there were smaller lakes near the Baikal basin, but these were always populated by widely distributed contemporary species of which there is no trace in Baikal.

Leaving the possibility of invasion from adjacent ponds and lakes, let us now consider the alternative, that of the capture of the drainage of Baikal by different major river systems, with consequent possibility of multiple introductions. There is no evidence that Baikal has even been a part of any system other than the Yenesei. The present outlet, the lower Angara River, flows from the southern basin, which is claimed to be older than other parts of the lake, a view which makes it probable that this is the original outlet. However, it is possible that the Angara once drained into the Lena, which at present has headwaters not far to the north, and that the Angara has subsequently been captured by the Yenesei. It is also possible that Baikal might have drained NE, through a reversal of flow in the upper Angara, into the Vitim, a tributary of the Lena. Should these or any other connections with the Lena have occurred, they do not provide an explanation of the large species flocks.

It is of interest to note here that all evidence indicates that the Angara-Yenesei River system which drains Baikal has supplied only one gammarid to the lake, while it has been invaded by numerous species which have almost certainly evolved in the lake. Its gammarids, triclads, molluscs, sponges, and bryozoans are all similar to Baikalian stocks. Among the gammarids (Dorogostaisky, 1916) and snails (Lindholm, 1912) living in the Lower Angara near Irkutsk the usual Siberian species are known to be wanting. Although many of its organisms are similar enough to be placed in the same species as the lacustrine forms, five Angara gammarid populations are considered subspecies, one (*Hetergammarus brachyurus*) is specifically different, and one species has been placed in the fluvial genus *Fluviogammarus*. This Baikalian element was known, prior to 1923, as far as 200 km. down the Angara. Although a complete faunal study of the drainage system has not been published, the malacostracan fauna of the Yenesei River is known. Gurjanova (1929) found that three endemic species of amphipods which are common in the shallow waters of Baikal, namely, *"Echinogammarus" viridis*, *Brandtia fasciata*, and *Micruropus wahli*, can be found in the Yenesei system. Pirozhnikov (1931), in another examination of the gammarid fauna, did not find either of the last two species, although *Micruropus vortex* and *M. glaber* were present at the station sampled. *"E." viridis* was the only Baikalian species which Pirozhnikov found in the Yenesei River above the entrance of the Angara, although Gurjanova found *B. fasciata* both above and below. All of the gammarids found in the Yenesei are also found among the 27 species and subspecies that inhabit the upstream portion of the Lower Angara. The long narrow Yenesei Gulf of the Arctic Ocean is greatly freshened by the river, but the Baikalian species have been unable to colonize those waters, where nine species of euryhaline marine malacostracans are abundant. In the river delta at the head of the gulf elements of the two faunas meet. *Pontoporeia affinis* and possibly *Mesidothea entomon* are the only gulf species which have been able to invade these waters. Only one amphipod of Baikalian origin has succeeded in establishing itself here, and has diverged from the parent species *Brandtia fasciata* sufficiently to be differentiated as *Brandtia fasciatoides*.

The length of time during which the fauna of the Yenesei has been influenced by the Baikalian element is, of course, undetermined. At the time of maximum Pleistocene glaciation, the Angara and the upper part of the Yenesei System were in unglaciated territory, and the latest advance did not reach even the mouth of the Yenesei. Whether the Baikalian species invaded the river before, during, or subsequent to periods of glaciation is a problem which cannot as yet be answered, although a recent date is more probable.

We may therefore conclude that none of the possibilities of multiple colonization, whether singly or in combination, can account for the origin of the species flocks in Baikal. As the hypotheses of multiple colonization are untenable as an explanation of the evolution of the species flocks of Baikal, it is necessary to examine thoroughly the possibility of geographical speciation within the lake.

The distribution of bottom-living forms might be affected by geographical barriers within a single basin. The large species flocks in Baikal, the turbellarians, molluscs, cottocomephorids, and amphipods are all bottom-living animals. Their activities are as closely confined to the substratum as those of terrestrial animals are to theirs. Only a single species of gammarid, *Macrohectopus branickii*, has left the bottom community. Unlike the African rift lakes, where the bottom waters are devoid of oxygen, there is ample oxygen in Lake Baikal down to the maximum depth. The area of the substratum available for exploitation by bottom-dwelling forms has therefore a considerable vertical as well as horizontal extension. Within this tremendous range, it is possible that ecologically similar areas might be isolated for periods sufficiently long to permit their benthic populations to undergo considerable genetic divergence. Evidence for intra-lacustrine geographical speciation can only be the existence of geographical subspecies and allopatric, as well as sympatric, species within the lake.

The presence of closely-related species in the open water community, species which have undoubtedly evolved within the lake, is exceptional. Vereščagin (1926) has concluded that there are two species of pelagic *Comephorus* in Baikal, *baicalensis* and *dybowskii*. These constitute the only known exceptions (Vereščagin and Sidorychev, 1929). The habits of the two are similar. Both live only in the open waters of the lake well away from the shore and feed primarily upon *Macrohectopus*. Both range throughout the greatest part of the vertical extension of the open water community. Both are regularly found in the surface waters in winter, although in summer only *C. dybowskii* is to be found at the surface. The young are always there, but the adults migrate to deeper strata during the day. No statements on differences in the horizontal distribution of the two species have come to the attention of the reviewer. These two similar species maintain their identity because of a difference in the time of breeding. *C. dybowskii* reproduces in February–March, whereas *C. baicalensis* breeds during July–August. The only way in which these two species could have arisen is through separation of the lake into two basins, thus isolating two populations. Evidence that such a separation probably has occurred will be discussed in a later section.

It is indeed fortunate that Dorogostaisky realized the importance of learning as much as possible about the distribution of the species comprising the fauna of Baikal, so that we have a picture of the distribution of the bottom forms here as we have in no other large lake. He published the results of this investigation in 1923, presenting his findings, which were based primarily on the distribution of the amphipods, in terms of a series of vertical zones and horizontal regions of the bottom. Some species and subspecies were restricted to each of these vertical and horizontal divisions, while others extended through several divisions, either vertical or horizontal, or both. As the Baikal amphipods are the only freshwater species flocks whose intra-lacustrine distribution is known to any degree of completeness, it is essential that not only Dorogostaisky's conclusions but also the bases for these conclusions be clearly comprehended.

Of the 291 amphipod species stated by Vereščagin (1940) to live in Baikal, it has been possible to ascertain the generic assignments of 143, or about one-half of the stated total, from the taxonomic works of Dorogostaisky and Bazikalova, and from Berg's (1928) summary. The distribution of these 143 species among the 30 known genera is shown in Table 2. Dorogostaisky was able to discover the limits of distribution of 85 of these species. Although he found four vertical zones to which various species were limited, only the boundary between the deepest two is indicated on the map. The bottom of the lake within this 300 meter depth line is called the Central Abyssal Province. At least 33 species are restricted to it. Fifty-six species are known to be limited to the bottom shallower than 300 meters. Each of these species is, however, not found in all parts of this belt. On the basis of the differences in their distribution, Dorogostaisky has delimited five regions of the bottom shallower than 300 m. These regions are indicated in Fig. 1. The greatest length of shore belongs in the two large regions which Dorogostaisky labelled the Northern and Southern Provinces. He cited 26 species which are limited to the smaller Southern Province and 20 others limited to the Northern. The smaller provinces called Isle, Small Sea, and Selenga, have only six, three, and one species, respectively, restricted to them, but each of the last two is characterized as well by the presence of subspecies of otherwise homogeneous, wide-spread populations. Nowhere has Dorogostaisky reported the total number of species which are found in the shallow waters of all parts of the lake, although he does state that there are many such species.

The vertical distribution of the gammarids will be considered first. Dorogostaisky found that the vertical ranges of different species tend to have similar limits, which correspond to ranges of environmental characteristics such as temperature, amplitude of diurnal and annual fluctuations, light, and type of plant and nature of bottom sediments. The areas of distribution of other elements of the bottom fauna coincide with those determined from the distribution of the species of amphipods. On this basis he divided the bottom into four vertical zones: the Littoral, 0–5 m.; the Sublittoral, 5–50 m.; the Transitional, 50–300 m.; the Abyssal, 300–1800 m.

A brief description of the environmental characteristics of each zone and the morphological characteristics of the gammarids of each has been summarized from Dorogostaisky's paper. The Littoral Zone has the greatest diversity of bottom relief and physical conditions, i.e. temperature and light. Most of the bottom is pebbly, with occasional large stones. There are few sandy shores. The largest stretch of sand is near the mouth of the Selenga River, and similar deposits are found at the mouths of other large rivers and in the deep bays. These waters are seldom calm, as wave action is considerable. The amplitude of diurnal and annual temperature fluctuations is greatest here. The light intensity is high. Green algae (*Ulothrix zonata* and species of *Draparnaldia*, *Tetraspora*, and *Oedogonium*) and diatoms are the dominant producer organisns in this zone; vascular plants grow only in calm, protected places. The gammarids of this zone are mostly green or brown. Their bodies are compact and their appendages relatively short. Their eyes are brownish-green or black. "*Echinogammarus*" *melanochlorus* (Fig. 3, *11*) exhibits typical Littoral modifications.

The bottom in the Sublittoral is also diverse in character, with pebbly and sandy places as in the Littoral, and silty regions in deep bays and opposite the river mouths. Wave action is almost absent. The diurnal temperature fluctuations are much less pronounced, and the amplitude of the annual cycle is slightly less than in the Littoral.

TABLE 2

Vertical distribution of genera of gammarids in Lake Baikal
(Based primarily on Dorogostaisky, 1922, 1923, 1930, 1936)

GENUS		NO. SPECIES IN BAIKAL	NUMBER OF SPECIES CHARACTERISTIC OF			
			LITTORAL	SUBLITTORAL	TRANSITIONAL	ABYSSAL
"*Echinogammarus*"	Stebb.	$27^{B,D}$	4	7	4	5
Pallasea	Bate	$12^{B,D}$	3	2	3	2
Brandtia	Bate	4	$1^{(+)}$	1	1	–
Odontogammarus	Stebb.	7	—	4	2	1
Parapallasea	Stebb.	5	—	1	3	1
Hyallelopsis	Stebb.	many	many^{D}	many^{D}	–	1^{BZ_3}
Micruropus	Stebb.	$13^{B,D}$	+	+	–	–
Boeckaxelia	Schell.	4^{S}	–	3	1	–
Acanthogammarus	Stebb.	$11^{B}+$	–	many^{D}	5	–
Poekilogammarus	Stebb.	6	–	4	2	–
Carinogammarus	Stebb.	7^{B}	–	–	1	1
Ommatogammarus	Stebb.	4	–	–	3	1
Hakonboeckia	Stebb.	$2^{D,BZ_1}$	–	1	–	1
Microgammarus		+	+	–	–	–
Heterogammarus	Stebb.	4^{D}	–	1	–	–
Crypturopus	Dyb.(?)	3^{D}	–	3	–	–
Echiuropus		1^{B}	–	1	–	–
Carinurus	Sow.	6^{BZ_2}	–	1	–	–
Plesiogammarus	Stebb.	2	–	–	2	–
Gammarosphaera	Baz.	1^{BZ_2}	–	–	1	–
Gymnogammarus		1	–	–	1	–
Brachyuropus	Stebb.	3	–	–	–	2
Ceratogammarus	Sow.	$3^{D,BZ_3}$	–	–	–	3
Garjajewia	Sow.	$4^{D,BZ_1}$	–	–	–	4
Abyssogammarus	Sow.	9	–	–	–	9
Coniurus	Sow.	2^{BZ_2}	–	–	–	1
Polyacanthisca	Baz.	1^{BZ_2}	–	–	–	1
Gammaracanthus	Sow.	1	–	–	–	–
Spinacanthus	Dor.	4(?)	–(?)	–(?)	–(?)	–(?)
Macrohectopus	Stebb.	1	–	–	–	–Planktonic
Total no. of genera		30	6	15	13	14
Species		147+	8+	29+	29	33

KEY:
B—Berg, 1928.
BZ_1—Bazikalova, 1935.
BZ_2—Bazikalova, 1936.
BZ_3—Bazikalova, 1937.
D—Refers to works of Dorogostaisky.
+—(Dor., 1930) *Brandtia lata* is split into 6 horizontal, shallow-water subspecies.
S—Schellenberg, A., 1940.

Because of the great transparency of the water, this zone is well illuminated. *Chara* and bottom diatoms are here the dominant lower plants, green algae being rare. *Potamogeton* and *Ceratophyllum* and other vascular plants can occasionally be observed. The body color of gammarids of the Sublittoral is often yellow or red, although whites, greens, and browns do occur. The body tends to have a less well developed exoskeleton, and the appendages are relatively longer. Eyes are usually black, brown, red, or yellow, more rarely white.

In the Transitional Zone the bottom is more uniform, largely silt, with occasional patches of sand or pebbles. Here the environment is nearly static. Even annual temperature fluctuations are insignificant. Wave action does nor affect this zone. Very little light penetrates so deep. Diatoms appear to be the only photosynthetic plants which can exist here. The gammarids of this zone are most diverse in body form. The greater the depth at which they live, the longer are their appendages (Fig. 3, *8*, *12*). The most prevalent species are yellow and red, but there are many white ones. "*Echinogammarus*" *virgatus* (Fig. 3, *12*) is pink and white. The relative length of its appendages is apparent upon comparison with the Littoral species just above it.

The Abyssal Zone provides an unchanging environment, ever cold (3.2°–4.0°C.) and dark. Diatoms sometimes manage to live as far down as 500 m., and below this bacteria are the only plants. The abyssal gammarids are distinguished by their large size, long appendages, and poorly developed exoskeleton. As in the zone above, most are colored yellow or pink, although white prevails among the most profundal. Their eyes are either pigmented (black, blue, purple, red) and extremely large, or unpigmented and quite small.

Dorogostaisky has not given the vertical range of each species, but for each zone he listed the characteristic species, with particular emphasis on those forms with limited distributions. This information is summarized in Table 2. There are undoubtedly a few species found in many of these arbitrary divisions of the bottom, although Dorogostaisky provided little information on this point. *Boeckaxelia carpenteri* is one of the more widely spread species, which in its typical form is characteristic of the sublittoral of both North and South basins and has a subspecies *profundalis*, living in the Abyssal Zone of the Northern Province (Bazikalova, 1937). (For another subspecies see Fig. 3, *3*.) There are records of several species that live over the boundary of either zone adjacent to that characteristic of the species (Dorogostaisky, 1922). However, it is clear from this study that the area of distribution of the majority of species of amphipods is limited to a fraction of the total vertical extension which is exploitable.

The basis for the demarcation of various parts of the bottom of Baikal, shallower than 300 meters, was the presence of several recurring distribution patterns which Dorogostaisky discovered in his study of the distribution of the 56 species living along this strip of the bottom. Dorogostaisky implied that some populations have a wide, possibly a lake-wide, horizontal distribution, although he never enumerated them. Another distribution pattern is that of species, otherwise widely distributed throughout the lake, which have readily distinguishable subspecies in the region adjoining the mouth of Selenga River. These provide the basis for the differentiation of the Selenga Province. Many species are restricted to the shore of the southern basin while related species occur along the shore of the central and northern basins, except in the smaller provinces. A single known species is divided into Northern and Southern subspecies. The Northern and Southern Provinces are thus indicated. There are six species of gammarids known to be restricted to the shallow waters around the Ushkanii Islands. Dorogostaisky called this region the Isle Province. There is only one long stretch of open coast which has a biotic assemblage different from that of the Northern and Southern Provinces. This is the east coast of a part of the south and central basins adjoining the Selenga Delta, called the Selenga Province. The Small Sea, the body of shallow water between Olchon Island and the west coast, also has a fauna characterized by populations specifically or subspecifically different from those of the open coast. The bottom of the Small Sea constitutes the Small Sea Province.

Dorogostaisky considered that the fauna of the Central Abyssal Province was similar throughout. However, Bazikaloba (1937) showed that the differences in the composition of the amphipod fauna of the southern and central deeps, which Dorogostaisky believed due to inadequate sampling, are real. The 550 meter contour indicated on the map (Fig. 1) as a heavy pecked line, shows this division of the bottom below this depth into southern and northern regions.

It is of considerable interest to be able to determine the horizontal and vertical distribution, within this general pattern, of all the members of the species flocks, and it is disappointing to find that only a single genus is sufficiently well known. This genus, *Odontogammarus*, is well defined and consists of seven species (Fig. 4). Dorogostaisky considered that *Od. calcaratus* resembles the ancestral species most closely. *Od. calcaratus* is common in the southern half of the lake, but is also present in the north. It is most abundant at depths of 80–100 m. but can be found between 30 and 300 m., and therefore is characteristically Transitional. In the South there is another Transitional species, *Od. pulcherimus*, common between 30 and 200 m. *Od. korotnewi* has been taken at several places in the Northern Province, including the entrance to the Small Sea and around the Ushkanii Islands. It is commonest at depths of 80–100 m. In 1925 Dorogostaisky recorded *Od. brevipes* only from Chivyrkui Gulf, but in 1923 he listed it as characteristic of the Northern Province. However, in his introductory remarks (1923) concerning this province he stated that the Gulf of Chivyrkui and Bargusin may have to be considered as separate zoogeographic units, because of the unusual characteristics of their faunas. As no additional records are given, we must assume that *Od. brevipes* is restricted to Chivyrkui Gulf, at a depth of about 50 m. The fifth species, *Od. improvisus*, is found only around the Ushkanii Islands and near the entrance of Chivyrkui Gulf at depths of 80–100 m. The remaining two species live at greater depths than those aforementioned. *Od. margaritaceus* Dyb. is found primarily at great depths (150–1500 m.) in both the south and middle basins. *Od. demianowiczi* Dor. is restricted to an area of the bottom 200–400 m. deep near the "Great Cat" hole in the south basin. This body of information on the distribution of *Odontogammarus* is the most comprehensive data on the distribution of the members of any lacustrine species flock.

The pattern of distribution of the component populations of a genus or superspecies of gammarids is essentially the same as that seen among terrestrial animals, such as birds or insects. The origin of such a superspecies of freshwater amphipods is reasonably explained by the same scheme of geographical speciation which Mayr has deduced from the distributions of those terrestrial animals. Although the data for the distribution of other genera of amphipods are not as completely recorded as for *Odontogammarus*, Dorogostaisky has claimed that groups of closely related species within the genera *Pallasea, Micruropus*, and *Acanthogammarus* have similar patterns of allopatric distribution. This is also true of a group of subspecies of *Brandtia lata* all living in shallow water. Some of the closely related species are sympatric, as the areas of distribution of both *Od. pulcherimus* and *korotnewi* appear to overlap that of *Od. calcaratus*. It is noteworthy that both of these are considerably smaller than *calcaratus;* are indeed the two smallest species (see Fig. 4). Lack (1944) has pointed out that among birds closely related species which differ considerably in body and bill size often occupy the same habitat. But it is unusual to find such marked size differences in closely related species which are not sympatric. The area of distribution of *Od. demianowiczi* appears to lie within that of *Od. margaritaceus*, while the other species are allopatric, occupying different areas of the bottom (Fig. 5).

Interspecific competition undoubtedly plays the principal role in determining the distribution of these species of amphipods. This competition must be primarily for food, which must be limited on the bottom of such an unproductive lake. It is a general rule that two closely related species cannot occupy the same ecological niche (Gause's Principle). When two closely related but reproductively isolated species come together for the first time, there can be any of three consequences. One may exterminate the other. If they do not overlap completely in their exploitation of the available food, natural selection will favor those individuals which overlap the least. In this way the two populations will diverge in feeding habits until the degree of competition is so lessened that the two species can coexist. The size differences in the sympatric species of *Odontogammarus*, probably associated with differences in food size, illustrate this possibility. The third alternative leads to the development of vertically restricted ranges. If the two competing species have slightly different vertical ranges to which they are adapted, each again has a refuge in which it can always compete successfully with its rival. Natural selection will lead to the more complete exploitation of those parts of the vertical range where competition is reduced.

The restriction of a species to a part of its potential range by competition with a closely related species is nicely illustrated by the distribution of triclads in the mountain streams of the Balkans and South Italy. *Euplanaria gonocephala* (Dugès) and *Crenobia teratophila* (Steinmann) occur alone in some streams and together in others. When *E. gonocephala* is alone, it lives in parts of the stream

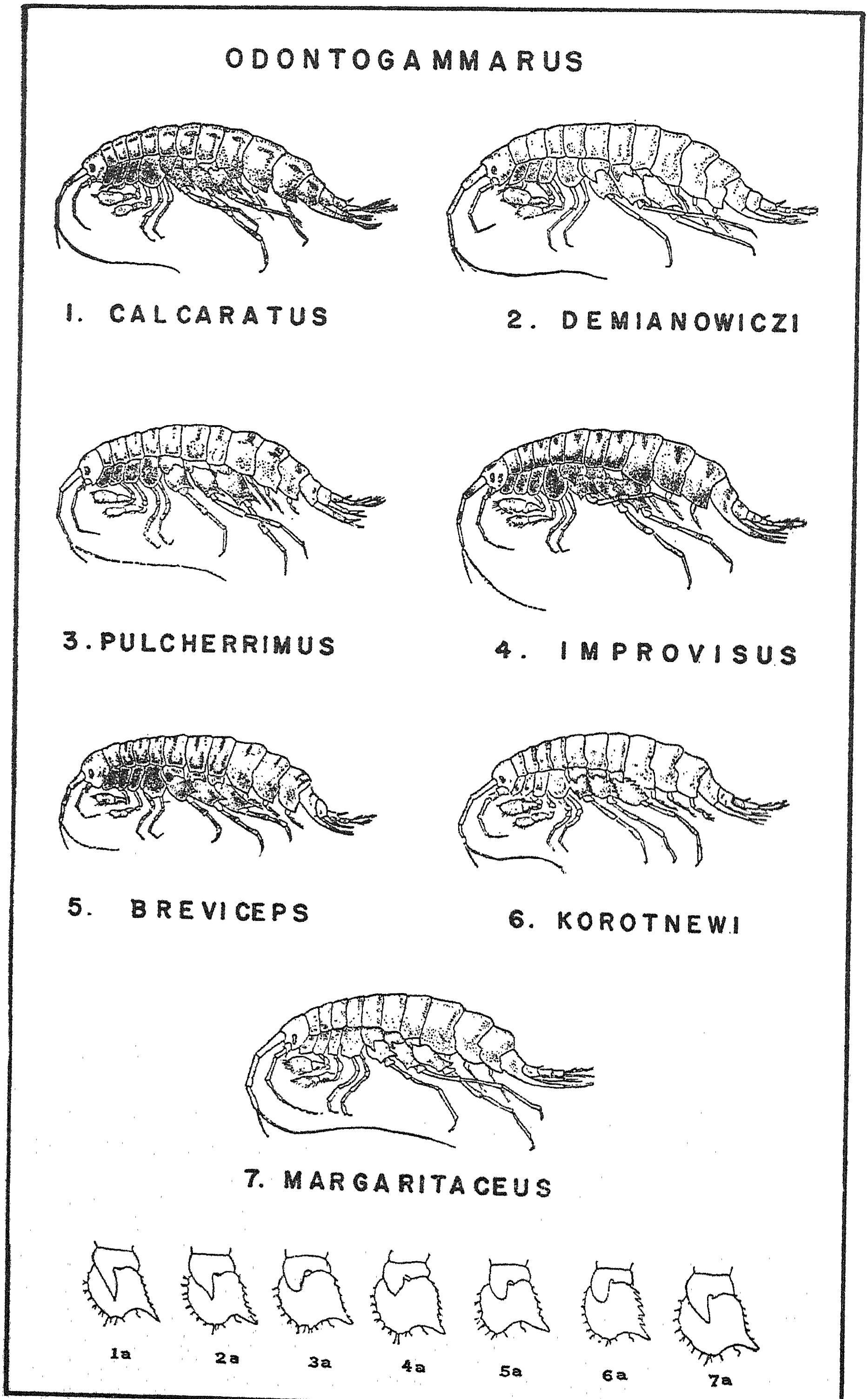

Fig. 4. Species of the Baikalian Genus, Odontogammarus

Distribution given in text. Body lengths: 1, 30 mm.; 2, 37 mm.; 3, 20 mm.; 4, 35 mm.; 5, 25 mm.; 6, 18 mm.; 7, 30 mm. 1a–7a, enlargements of the coxal plate and expanded basipodite of the 6th thoracic appendage of above species. (These figures, rearranged, from Plate 2 of Dorogostaisky, 1930.)

where the water temperature is between 8.5° and 23°C., whereas *C. teratophila* occurs in cooler waters, between 6.6° and 16.5°C. Whenever the two species inhabit the same stream, *C. teratophila* extends downstream only to places where the temperature is 13–14°C. Below the point where the water reaches this temperature, *E. gonocephala* replaces the former species and extends downstream until its upper thermal limit is reached. [Beauchamp and Ullyot, 1932. N. B. These authors named the Balkan species involved *Planaria gonocephala* Dugès and *Planaria montenegrina* Chickoff. They assumed the South Italian *Pl. teratophila* Steinmann to be synonymous with the latter. If this assumption is correct, the name should be *Crenobia teratophila* (Steinmann), according to Kenk, 1930.]

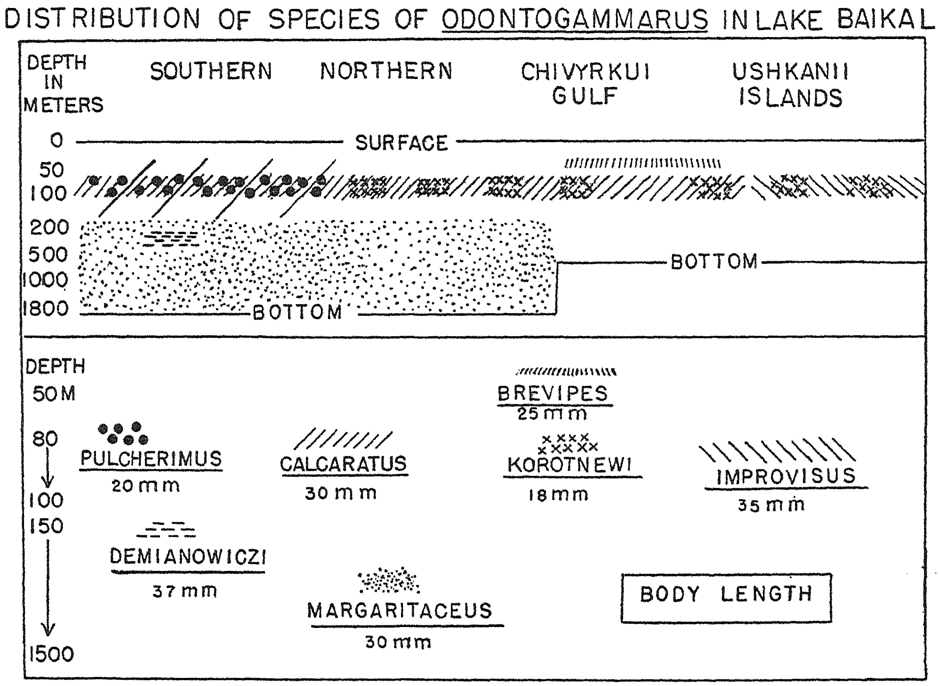

FIG. 5. A DIAGRAMMATIC REPRESENTATION OF THE DISTRIBUTION OF ODONTOGAMMARUS IN LAKE BAIKAL

THE ZOOGEOGRAPHICAL PATTERN IN BAIKAL

Mayr (1942) has likened old freshwater lakes to old islands, because each permits the survival of conservative elements of otherwise extinct faunas. The comparison is equally useful when each is considered as a geographical region within which speciation can occur; as when, for example, Lake Baikal is compared with New Guinea. The bottom fauna of the Littoral, Sublittoral, and Transitional Zones of Baikal are as completely isolated by the open waters of the lake from those on the other side as the birds living near sea level on one side of New Guinea are isolated by the central mountains from those on the other side. The differentiation of the Abyssal fauna in the south and central basins has its counterpart in the differentiation of the mountain bird fauna in different ranges of the central New Guinea mountains (cf. Mayr, 1942, Fig. 24). The strips of low and middle altitude land around the periphery of New Guinea, like the Littoral, Sublittoral, and Transitional Zones around Baikal, each have a tremendous linear extension. Any vertically limited population spreading out in any one of these ecological zones will result in an essentially linear population. Such linear populations are prone to geographical speciation. The results of speciation in the birds of New Guinea are admirably illustrated in Mayr's (1942) Fig. 4, showing subspeciation in the whistler *Myiolestes megarhynchos*, his Fig. 15 of the kingfisher *Tanysiptera galeata*, and his Fig. 13 of the races of *Paradisea apoda*.

The long strip of lake bottom adjacent to the shoreline of Baikal passes through regions with different ecological conditions. Any Littoral or Sublittoral species spreading along the shore will encounter a variety of environments, which they may or may not be capable of invading successfully. An examination of the distribution of the Baikalian gammarids has shown that certain species and subspecies are restricted to certain geographically delimited regions of the lake shore. The fact that many of the amphipods have peculiar species or subspecies restricted to the same sections of the shore made it possible for Dorogostaisky to name these regions and to present the distributional data in relation to them. In order for these populations to have diverged genetically, they must be discontinuous or have been so at some time in the past.

The shallow shore around the Ushkanii Islands is one area which is at present geographically isolated from the rest of the shallow bottom areas of the lake. There is only a narrow strip of bottom shallower than 300 m. joining this shallow area with that of the Holy Nose Peninsula. This Isle Province is ecologically distinct as well, for the temperature of the surface water here seldom rises above 7°C., according to Dorogostaisky. "The fauna of the Isle Province is well characterized by many endemic species" (trans. Dorogostaisky, 1923, p. 121). This endemism is especially evident in the gammarids and turbellaria, although the species of the latter group are largely undetermined. Six species of gammarids are restricted to the Isle Province, *Spinacanthus insularis* Dor., *Boeckaxelia castanea* Dor., *Acanthogammarus maximus* Sar., *Ac. korotnewi* Sar., *Gammarosphaera insularis* Baz. (Bazikalova, 1936), and *Odontogammarus improvisus* Dor. No subspecies are reported, and the presence of representatives of widely spread species was not mentioned. *Spinacanthus insularis* is Sublittoral, and *B. castanea* occurs in both the Sublittoral and Transitional (Dor. 1930). *Acanthogammarus korotnewi*, *Gammarosphaera insularis*, and *Odontogammarus improvisus* are characteristically Transitional. No data are available for *Ac. maximus*. Although Dorogostaisky lists *Hyalellopsis*, *Micruropus*, and *Microgammarus* as characteristic of the Littoral and Sublittoral Zones of the lake in general, no representatives of these genera are recorded from the Isle Province. Possibly the physical environment of the Littoral and upper Sublittoral of the Isle Province is sufficiently different, so that these genera, adapted to the conditions of these zones along the main shore, have been unable to establish themselves. Otherwise it must be assumed that suitable invasion routes have been wanting for a long time relative to the age of the islands.

Each of the other small provinces is ecologically distinct from the adjacent Northern and Southern Provinces, but all are geographically continuous in the same way that the lowlands of New Guinea are continuous. Yet it is apparent from the degree to which subspeciation and speciation have occurred that the populations along these geographically continuous strips must be more or less discontinuous. This is equally true of the birds of the New Guinea lowlands and the gammarids of the shallow bottom of Baikal.

Differences in the nature of the sediments of the shallow bottom are readily apparent. The bottom of the Littoral and Sublittoral Zones which, along the open coasts of the Northern and Southern provinces, is largely rocky and pebbly, is considerably modified in deep bays such as Bargusin and Chivyrkui, and at the mouths of the large rivers, such as the Selenga, Upper Angara, and Chivyrkui. In these places the Littoral bottom is sand, and the Sublittoral sand and silt. Even the Transitional Zone may be altered.

The longest stretch of sandy bottom extends on either side of the Selenga delta and constitutes the Selenga Province. Here the water itself is turbid, very different from the highly transparent water along most of the shore, and the temperature in summer is higher than it is along the open shore. The surface temperature here may reach 19°C. It is not surprising that the fauna of this region has a peculiar aspect. Sponges and turbellarians have not been able to establish themselves in this environment. Thirteen species of amphipods have been recorded from this region, and of these, seven are morphologically indistinguishable from samples taken elsewhere in the lake. However, five widely distributed species are represented in the Selenga region by peculiar subspecies [*Pallasea baicalia inermis* Sow., *P. grubei arenicola* Dor., *Carinurus solskii obscurus* Dor., *Parapallasea puzylli carinulata* Dor., and *Acanthogammarus godlewski brevispinus* Dor. (Fig. 3, *10*)]. *Boeckaxelia potanini* Dor. (Fig. 3, *4–5*) is the one species restricted to this province. It is Sublittoral.

The nature of the populations at the boundaries of the adjacent Southern and Northern Provinces has not been investigated. For these Selenga populations, which have only subspeciated, it is reasonable to assume that either genetic interchange with the adjacent population is not completely interrupted, or, if it has been interrupted, that sufficient time has not elapsed for the more profound morphological differentiation to have occurred which would be considered speciation.

The two large gulfs on the eastern coast of the Northern Province resemble the Selenga region in certain aspects. Here, too, the bottom is largely sand and silt, and the summer temperatures are much higher than those along the rest of the shore of the Northern Province, for they reach 20°C. (Dor.) Dorogostaisky stated in 1923 that each gulf appears to have its own faunal characteristics, although the amphipods had not been adequately studied at that time. Subsequently Dorogostaisky (1936), in a paper which could not be consulted in the original, published the results of a study of the gammarids of Bargusin Bay. According to the *Zoological Record* a new species, *Micruropus cristatus*, was described, apparently confirming the distinctness of this region of the bottom. It was previously noted that *Odontogammarus brevipes*, although listed (1923) as characteristic of the Northern Province, apparently has been found only in Chivyrkui Gulf (Dor., 1925).

The Small Sea, on the west coast of Baikal, should undoubtedly be classed with the gulfs on the east coast when considering geographical speciation. The Small Sea is not a gulf, inasmuch as it communicates with the open waters of the lake at both ends. The narrow Olchon Gate at the south end of Olchon Island must be considered a part of the Small Sea. This province presents a wide variety of physical conditions, viz., nature of bottom, depth, temperature, and transparency, matched by the diversity and richness of the flora and fauna (Dor.). The vascular plants are well represented here. Although no study has been made of the productiveness of different parts of the lake, it appears that the Gulfs of Chivyrkui and Bargusin and the Small Sea support the largest populations. This is evidenced by the fact that *Manajunkia baikalensis* is extremely abundant in the Transitional zone of the Small Sea and the Gulf of Chivyrkui, but exists elsewhere in sparse populations. Dorogostaisky reports that the planaria are particularly abundant here, listing 33 species. Although 51 species of gammarids occur in the Small Sea (Burow and Koskow, 1932), only about 14 are very common and of these the following are endemic: *Pallasea bicornis* Dor. (Fig. 3, 7), *Hyalellopsis depressirostris* Sow., *Microgammarus chargaensis* Sow., and *Acanthogammarus armatus ongureni* Gar. (Dor.). The typical subspecies of the last, *Acanthogammarus armatus armatus*, has been taken only in the Northern Province (Dor., 1922). The populations of the majority of non-endemic species of the Small Sea consist of individuals morphologically distinguishable from those living in other parts of their range (Burow and Koskow, 1932).

In addition to these large reaches of shallow water, there are several smaller shallow bays along the east coast which are very productive, but whose faunal assemblage is non-Baikalian. Three of these near the Selenga delta, the bay of Proval and Kharauz and Posolsky lagoons, are indicated on the map. Although they are all broadly connected with the main part of the lake, the biota, both planktonic and benthic, is completely different, being comprised of common Siberian species (Dorogostaisky). This is also true of the lakes Froliha, Rangatui, and Katokel, which flow directly into Baikal, and of the many ponds in the Selenga delta. Only a single Baikalian endemic, *Brandtia fasciata*, has successfully invaded these waters, and the common palaearctic gammarid, *Gammarus* (*Rivulogammarus*) *pulex* is abundant. The littoral environment in Baikal is sufficiently different from that of these adjacent bodies of water that the species adapted to the one apparently cannot compete successfully in the other.

There is only one place in the shallower bays of Baikal where representatives of common palaearctic genera have been able to establish themselves, and this is on the shallow bottom fringing the Small Sea (Burow and Koskow, 1932). However, certain of the palaearctic elements common in the small lakes and bays noted above are absent here, being replaced by ecologically similar forms of Baikalian genera. *Gammarus* (*R.*) *pulex*, for example, is never found, its place being taken by littoral species of the Baikalian genera *Brandtia*, "*Echinogammarus*," and *Micruropus*. It is interesting that one of the commonest of these species is *Brandtia fasciata*, which has also been able to invade ponds and lakes connected with Baikal and has spread through the Yenesei River System. "*Echinogammarus*" *viridus*, common in these very shallow baylets of the Small Sea, has also invaded the Lower Angara River and thence the rest of the Yenesei System. The bottom fauna farther away from the shores has few palaearctic species, and in the deeper waters is entirely replaced by a typical Baikalian association.

The fauna along the coast to the north and south of the Small Sea, as well as on the outer side of Olchon Island, is all classed as Northern by

Dorogostaisky. An intensive study of the fauna of the Small Sea by Burow and Koskow (1932) has shown it to be more closely related to that of the Northern than to the Southern Province. There are no data recorded concerning the intermixing of the two faunas at the mouths of the Small Sea.

We now come to the problem of the origin of the Southern and Northern faunal provinces. On the west coast, the Southern fauna is gradually replaced by the Northern fauna about one third the way up from the south end, while the Selenga Province separates the Northern and Southern Provinces on the east coast. There are no large bays in the Southern Province, and its bottom shows little variation, being rocky in the Littoral and upper Sublittoral, becoming sandy in the lower Sublittoral. Excepting the two gulfs and a sandy stretch on the northern end of the lake, the bottom in the Northern Province is very similar. Other physical conditions are also similar, except that the shallow waters at the extreme southern end of the lake attain a higher summer temperature than elsewhere. The two principal provinces therefore show, at the present time, none of the essential ecological differences that are associated with the smaller provinces. Furthermore, the transition from Northern to Southern faunas on the west coast is gradual and not marked by any conspicuous geographical features.

The problem of the origin of the species of the Northern and Southern Provinces is different from that in the other small ones. In the latter there are small numbers of species and subspecies restricted to portions of the lake, each of which not only has its own ecological peculiarities but enjoys partial geographical isolation from the rest of the lake. There is also a correlation between the degree of geographical isolation and the ratio of endemic species to subspecies. In the isolated Isle Province all six of the endemic populations are ranked as species, while in the Selenga Province, geographically continuous with both the Northern and Southern Provinces, there is one endemic species to five endemic subspecies. The Small Sea is intermediate between these extremes, both with regard to degree of geographical discontinuity and relative extent of speciation. There is no genus restricted to any one of these small provinces; all of their endemics have closely related species in the adjacent Northern, and in the case of Selenga, both Northern and Southern faunas. The present conditions of discontinuity are such that we might expect the bottom populations in the smaller provinces to be in the process of subspeciation and possibly speciation. On the other hand, the Northern and Southern Provinces, ecologically very similar to each other and broadly continuous at least on the west coast, have 20 and 25 species restricted to each, respectively, and only a single common species represented by two geographical subspecies. *Acanthogammarus victori* Dyb. is recorded by Dorogostaisky to have Northern and Southern subspecies. The presence of large numbers of restricted species and the apparent lack of present subspeciation, together with the lack of any geographical features which might cause isolation, is most reasonably interpreted as indicating that the differentiation of the Northern and Southern species occurred at a time in the past when the morphometry of the lake was different from what it is at present. And as a corollary, the Northern and Southern faunas must be older than those of the smaller provinces, which appear to be still in the process of subspeciation and speciation.

In our endeavor to ascertain the past existence of any morphometric feature of Lake Baikal which might isolate the Northern and Southern Provinces, it is necessary to include a consideration of the Abyssal zone. Although Dorogostaisky was of the opinion that the species of the south and middle depressions (Fig. 1) were identical, Bazaikalova (1937) has reported that several species are restricted to one of the two depressions. *Garjajewia dogieli* Baz., *Abyssogammarus leptocerus* Dyb., *Ab. sarmatus* var. *echinatus* Baz., *Ab. hydiae* Baz., and *Ab. kusnezowi* Sow. are peculiar to the southern depression, while *Polyacanthisca calceolata* Baz. (a monotypic genus resembling *Abyssogammarus*), *Ceratogammarus acerus* Baz., *Abyssogammarus gracilis* Sow., *Ab. calceolatus* Sow., and *Boeckaxelia carpenteri* f. *profundalis* are found only in the middle depression. The shallow water between the two depressions stands over the Selenga Rise, which extends from the mouth of the Selenga River on the east coast to the Buguldeika River on the west coast. It is not at all clear how shallow the Selenga Rise is. Drizhenko's longitudinal profile (in Fickeler) indicates its top as 150 m. below the surface, while a transverse profile about 80 km. north of this 150 m. sounding shows very shallow water on the eastern end, gradually deepening to a maximum of 530 m. three quarters of the distance toward the west shore. This may mean that there is a shallow ridge running obliquely to the transverse sounding line.

The transition from Southern to Northern bottom fauna in the Littoral and Sublittoral zones on the west coast takes place over the end of the Selenga Rise, which we have seen separates the Abyssal faunas. Although Dorogostaisky drew the line of demarcation somewhat to the north of the rise at the Cape of Krestovsky, he stated that this replacement of one fauna by the other is in reality gradual. Furthermore, he stated that the northern and southern subspecies of *Acanthogammarus victori* meet at the Buguldeika River, which is very near the west end of the rise. The fauna of the Selenga region, which like that of the Small Sea is probably of relatively recent origin, now separates the Northern and Southern faunas on the east coast, so that we can learn little about the eastern end. It may be fortuitous that the Southern assemblage of bottom amphipods living above 150 meters should be replaced by the Northern assemblage at the same place where a barrier separates the Abyssal fauna of the southern basin from that of the northern part of the lake, but it is also possible that at some time in the past the top of this ridge was nearer to the surface and acted as a barrier for the fauna of the shallower waters as well. This would involve either a lowering of the water level or an elevation of the ridge, or both. Until we know more of the structure of the rise it is impossible to evaluate these possibilities.

Drizhenko's (1908) map and profiles provide the little information available, and two geomorphic interpretations of the structure of the rise have been presented, based upon these diagrams above. Fickeler (1927) and Halbfass (1928) are of the opinion that this rise is formed of sediments deposited by the Selenga River. Johansen (1925) supported this interpretation but did mention the possibility that this rise may be of tectonic origin. Bazikalova (1937) referred to it as a submarine mountain range, but without reference to any geological study. Burow and Koskow (1932) stated that in their opinion it is possible that the Northern and Southern parts of Baikal were isolated from each other at some time in the past, but they made no mention of the implied geographical barrier. It is of the utmost importance that the structure of the rise be more thoroughly investigated, in view of the biological evidence that a barrier has existed at this place in the lake.

Gradual replacement of the Southern by the Northern faunas along the west coast is the pattern to be expected, following the removal of a barrier which had persisted long enough for reproductive isolation to evolve. The closely related species would compete, and a Southern species might extend its range at the expense of that of the Northern member of the subspecies, or vice versa. It has already been stated that at least one species, *Acanthogammarus victori* Dyb., has two geographical subspecies which replace each other near the mouth of the Buguldeika River, somewhat to the south of Cape Krestovka, through which Dorogostaisky drew the dividing line. On the other hand, some Southern species extend as far north as the southern side of the Olchon Straits (Burow and Koskow, 1932).

Should the geological structure of the Selenga Rise prove consistent with the hypothesis that it was at one time a barrier separating Baikal into two lakes, the otherwise inexplicable origin of two pelagic species of *Comephorus* will have a reasonable explanation. During this period of separation the two stocks could have acquired their different breeding seasons, so that they remained reproductively isolated when the geographical barrier disappeared.

Summarizing this investigation of the geographical aspects of the speciation of gammarids in Lake Baikal, it may be said that the ranges of distribution of the restricted subspecies and species of the Littoral, Sublittoral, and Transitional zones are either closely associated with geographical features of the present coastline or, showing the same pattern of distribution, indicate that at some time in the past the lake was completely, or very nearly, split into two lakes which have been subsequently reunited. This barrier is not entirely hypothetical, as there is at the present time a barrier effectively subdividing the Abyssal fauna in the very part of the lake in which a shallow water barrier at some time in the geologically recent past is required. There is every indication that the basin of Lake Baikal has had a long and complex geomorphic past (Presniakov, 1940), only the latest phases of which are indicated by the intra-lacustrine distribution of the present fauna. It is a reasonable assumption that there have been geographical subspeciation and speciation associated in the past with geographical features which acted as barriers to the distribution of once-continuous populations, just as there is at present. With the passage of time these isolated subpopulations may have been re-joined or further subdivided, as the barriers vanished and were replaced by new ones, giving rise to the large species flocks.

DISTRIBUTION AND SPECIATION OF OTHER BAIKALIAN SPECIES FLOCKS

The information which Dorogostaisky was able to gather about the distribution of the other species flocks is less extensive than for the gammarids. We will consider each group, however, in an endeavor to ascertain the probability of geographical speciation.

All but one species of cottocomphorids are bottom forms. Taken as a group they cover the entire vertical range, but individual species are restricted in their vertical distribution. The known vertical distribution of the benthic cottids is given in Table 3. It is not surprising that none of the cottocomephorids are restricted to the narrow Littoral zone, nor that the young of two species feed there. The restriction of the species of *Cottus* to this narrow zone may be the result of the inability of this recent invader to successfully compete with the adult cottocomephorids of the deeper waters. Adult *Batrachocottus baicalensis* may be excluded from the Littoral zone by such competition, but judging from the deep distribution of most of the cottocomephorids, their absence from the Littoral and their unique representation in the Sublittoral are more probably due to other factors. *Procottus* and *Batrachocottus*, which form a group serologically different from the other Abyssocottini, have a shallower distribution. The young of a single species of *Procottus* and the Sublittoral species of *Batrachocottus* are known to migrate up to the Littoral zone. It is not known whether this habit of vertical migration is restricted to these two related species or whether it may also occur in other species but has escaped detection because the shallowest waters are not penetrated. The vertical discreteness of the ranges of the three species of *Batrachocottus* (Fig. 2, *19–21*) has no parallel in the polytypic genera of the other serological group, both species of *Limnocottus* (Fig. 2, *15–16*) and the three of *Abyssocottus* being restricted to the Transitional and Abyssal zones, respectively. The abyssal monotypic genus *Asprocottus* belongs to this latter group, but the affinities of *Metacottus* and *Cottinella* have not been investigated.

TABLE 3

Vertical distribution of some cottoid fish in Lake Baikal

VERTICAL ZONE	SPECIES
Littoral	*Cottus kessleri* Dyb. *Cottus kneri* Dyb. Young *Procottus jeittelesi* (Dyb.) Young *Batrachocottus baicalensis* (Dyb.)
Sublittoral	*Batrachocottus baicalensis* (Dyb.)
Transitional	*Procottus jeittelesi* (Dyb.) *Batrachocottus nikolski* (Berg) *Limnocottus godlewskii* (Dyb.) *Limnocottus megalops* (Graz.)
Abyssal	*Batrachocottus multiradiatus* Berg *Asprocottus herzensteini* Berg *Abyssocottus korotneffi* Berg *Abyssocottus gibbosus* Berg *Abyssocottus boulengeri* Berg *Metacottus gurwičii*

Dorogostaisky reported that there was no information on the horizontal distribution of the cottocomephorids prior to 1923, and none has appeared since. We would not expect to find many geographical subspecies and allopatric species because of their deep distribution and their motility, which is probably greater than that of the invertebrates. However, it does seem likely that careful investigation might demonstrate that the southern and middle depressions, whose isolation has led to a divergence in the gammarid populations, are different with respect to their cottocomephorids. The presence of more species in the more completely isolated Abyssal than in the Transitional would be expected, and these zones have seven and four species, respectively. The distribution of *Comephorus* has been previously discussed.

Unlike the cottocomephorids, the Baikalian molluscs do not occur in the Abyssal zone, and find their greatest development in the Sublittoral. The Littoral species all belong to the non-endemic genera of gastropods and pelecypods. Indeed, all but two of these genera are restricted to this shallowest water. At least one species of *Ancylus* and three of *Valvata* are reported by Dorogostaisky to inhabit deeper waters. The large endemic genera of gastropods, *Choanomphalus* and *Baicalia*, appear to be most numerous within the Sublittoral, although some species of the latter extend into the Transitional. Dorogostaisky gives the vertical distribution of only one of the 15 species of *Choanomphalus*, namely, *maacki*, which is Sublittoral. Burow and Koskow (1932) indicate that four of the six species of this genus found in the Small Sea live between 3 and 18 m., with one species above and one below. The smaller genera *Benedicta* and *Kobeltocochlea* (Fig. 2, *1–4*) are Sublittoral and Transitional, and in the former we find the only recorded instance of two closely related species of gastropods showing a restriction of their vertical ranges. Dorogostaisky listed *B. baicalensis* as characteristically Sublittoral and *B. fragilis* as Transitional.

It is regrettable that so little is known about the horizontal distribution of the Baikalian molluscs. Dorogostaisky was able to ascertain the distribution of only 19 of the many molluscs of the Northern and Southern Provinces, and those of the smaller provinces has been studied even less. The subsequent work on the Small Sea (Burow and Koskow, 1932) makes it possible to draw some tentative conclusions about distribution and speciation in the molluscs. It is of interest that 6 of the 7 recorded Baikalian species belonging to non-endemic genera are restricted to either the Northern or the Southern Province. Two species of *Limnea* and one each of *Planorbis* and *Physa* are characteristically Northern, while one *Ancylus* and one *Valvata* are numerous only in the Southern Province. Did these invade Baikal while it was two lakes? The seventh species *Valvata baicalensis* has been found in both Northern and Southern Provinces, as well as the Small Sea. *Choanomphalus maacki* is the only member of an endemic genus with a similarly unrestricted distribution. None of the common snails of endemic genera are restricted to the Southern Province, while the genus *Benedictia*, if it does occur there, cannot be very common. The Sublittoral *B. baicalensis* Gerstf. has been found in the Northern Province and in the Small Sea, and the Transitional *B. fragilis* is not found in the Small Sea, whose bottom is entirely Sublittoral.

In the Small Sea, the only province for which a complete faunal list is available, 20 species of *Baicalia* occur. One of these, *B. ciliata* (Fig. 2, *6*), was recorded by Dorogostaisky as characteristic of the Southern Province; another, *B. oviformis*, as characteristic of the Northern. Two other species not found in the Small Sea were listed by Dorogostaisky as being common elsewhere. This fragmentary information indicates that there are allopatric species in the large endemic flocks and that geographical speciation must be considered as possible.

The turbellarians and oligochaetes have been so imperfectly studied from the standpoint of distribution that little need be said of them here, save that there appear to be many allopatric species. Representatives of both groups can be found at all depths in the lake. Dorogostaisky recorded a total of 33 species of turbellarians as characteristic of either the Northern or Southern Province, but none as characteristic of both. Another 32 species were stated by him to be characteristic of the Small Sea, and all are different from those of the Northern and Southern Provinces. Burow and Koskow did not study the turbellaria here. Dorogostaisky reported the presence in the Isle Province of many species of turbellarians not found in other parts of the lake. Those of the Selenga Province are unstudied. Nasonov (1930) recorded the localities where the species of the rhabdocoel *Baikalellia* were found in the Olchon Gate and in the southern basin. This, however, was not primarily a distributional study and did not purport to give the complete distribution of these species. Although Dorogostaisky provided considerable information on the vertical distribution of the oligochaetes, the only clear indication of regional differences in the oligochaete fauna is found by comparing Michaelsen and Vereščagin's (1930) study of the Selenga region and the northwest coast of the lake with that of the Small Sea by Burow and Koskow (1932).

The taxonomy of the Baikalian isopods and ostracods was imperfectly known in 1923, so that the scant information on the distribution of the members of the species flocks of these two groups has become available since Dorogostaisky's paper. Dorogostaisky made no mention of the ostracods, and knowledge of the taxonomy and distribution of these bottom living crustaceans is due to Bronstein's efforts. Although the patterns of ostracod distribution within Baikal have not been comprehended, it appears from the distributional data presented in Bronstein's 1930 paper that some members of ostracodan species flocks are sympatric, while others are allopatric. The picture of isopod taxonomy and distribution is more complete than it was in 1923, when Dorogostaisky considered that there was only one Baikalian species. Five species are now known. *Asellus dybowskii* Semenkewitsch, which Birstein (1939) separated from the other four Baikalian species into the subgenus *Mesoasellus*, was found in the Abyssal zone of the southern basin at a depth of 800 to 1000 m. The four species of the endemic subgenus

Baikaloasellus live in much shallower water, according to Semenkewitsch (1924). *A.* (*B.*) *angarensis* Dyb., the commonest species in Baikal, lives at depths of from 1.5 to 45 m. Although it has been found along the entire coast, it is much more common in the northern and central parts of the lake than in the southern. *A.* (*B.*) *baikalensis* Grube, like the preceding species, can be found throughout the lake, also living between rocks and stones, but it is much more common in the southern part of the lake. This pattern of distribution might be the result of the interpenetration of two closely related species which had diverged while separated into southern and northern subpopulations. It would be of considerable interest if the ecological relationship of these two species could be more intensively studied. The last two species have much more restricted ranges. *A.* (*B.*) *korotnewii* has been taken at several places in the Small Sea and near the Holy Nose Peninsula. Whether or not these latter collections were in either of the gulfs formed behind the Holy Nose Peninsyla was not stated by Semenkewitsch. This species was found on a very shallow stony bottom, at depths of 1–9 m. The known range of *A.* (*B.*) *minutus* is even more restricted, since it was found in only one collection in the south basin near the beginning of the Lower Angara River. A more careful delimitation of the ranges of these two species might provide some idea of the nature of the barriers between these and the two more widespread species.

It would be of considerable interest to compare the pattern of distribution of the bottom-dwelling harpacticoid copepods with that of the other elements of the bottom fauna, but this reviewer was unable to find any pertinent information. Borutzky gave no distributional data. Since Vereščagin (1940) listed 37 species (see Table 1) further work must have been done.

From this brief summary of the other Baikalian species flocks, it is evident that a great deal of work must be done before the distribution patterns for each species flock are established. It is clear that in the better known groups of bottom fauna, geographical speciation associated with the same geographical isolating mechanism which appeared in the study of the gammarids, must be considered not merely possible but also highly probable.

(*To be concluded*)

NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will occasionally appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to H. B. Glass, Associate Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

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GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

THE SITUATION IN BIOLOGICAL SCIENCE. *Proceedings of the Lenin Academy of the Agricultural Sciences of the U. S. S. R., July 31–August 7, 1948. Complete Stenographic Report.*

By T. D. Lysenko and others. International Publishers, New York. $5.00. ii + 636 pp. 1949.

THE SCIENCE OF BIOLOGY TODAY.

By Trofim Lysenko. International Publishers, New York. $1.25. 62 pp. 1948.

The most remarkable fact about the last public outbreak of the so-called "Genetics Controversy" in Russia, of which this book is a verbatim transcription, is the utter confusion of science on the one hand and political and social passion on the other. It may, in fact, take its place in history as one of the documents in the struggle between science and politics, a struggle which in our time has come to occupy the central position of (although not entirely superseding) that struggle between science and theology which agitated our grandparents. The fact of greatest importance recorded in these 636 pages, which contain the speeches delivered by 56 participants in the debate of July 31–August 7, 1948, is the loss not merely of a science, but of that objectivity and detachment toward which Western scientific culture has struggled for three centuries. This conclusion has to be drawn from the documents on both sides of the controversy, not only pro and con in Russia, but pro and con in the United States, in Great Britain, in Germany, and in Austria, to name only the countries from which this reviewer has received published material on the debate.

It is difficult, after the passions of opposing parties have been aroused, to rid such a controversy of the strong colors (chiefly bright red and pure white) which have been given to it by the press and personal accounts; yet that seems to me to be the first duty of a reviewer. What is important just now is not only whether this one was "right" and that one "wrong," whether this one lied and that one was honest, for time will render that judgment better than we can at this moment; it is rather to know what the controversy was and why it broke out when and where it did. It is better now to report and to understand than to judge.

The documents in this book leave no doubt as to who began this fight or who the aggressors were. They were the supporters of the agronomist Trofim Denisovich Lysenko, who had begun in the late twenties to publish results of experiments on plants which led him to believe that the heredity of crop plants could be permanently altered by the proper manipulation of certain factors of their environment, such as temperature, amount of daylight or of fertilizer, or time of planting. This conclusion had already been drawn by Lysenko's predecessor and inspirer, the old horticulturalist Michurin, and in the long first speech in the 1948 debate, which has already been published separately (second title above). Lysenko, now President of the Lenin Academy of Agricultural Sciences and Director of the Institute of Genetics, speaks of this doctrine as Michurinism, and all of his supporters, most of them young men, can be recognized by the slogans which are reiterated in identical form throughout their speeches. "The future belongs to the progressive Soviet Michurinism." These aggressive debaters are ranged against a rather shadowy contingent called "the Mendel-Morgan-Weismann reactionary bourgeois geneticists." These are the persons who first defended the doctrines of modern genetics in the debates of 1936 and 1939. However, when one examines more closely the participants in the 1948 debate, one finds that this last battle in the "genetics" war was fought practically without geneticists on either side. The 47 who supported Lysenko's (Michurin's) theses about the inheritance of direct effects of the environment are a motley assemblage of agronomists, physiologists, biochemists, agricultural engineers, and chiefly plain agricultural politicians, with intellectual stiffening supplied by some professors of philosophy; while the men who did not, at least at first, bind themselves completely to the chariot wheels of Lysenko, i.e., "the geneticists," comprise a statistician (Nemchinov), an endocrinologist (B. M. Zawadowsky), an embryologist (Schmalhausen), two plant breeders (Zhukovsky and Zhebrak), and one unclassified biologist who, however, sat so uncomfortably on the fence that his special competence is unimportant (Polyakov). Only two, Rapoport and Alikhanian, could be called geneticists in in any proper sense, as being persons primarily concerned with the principles of genetics. The chief Soviet geneticists—such as Dubinin, Tschetverikov, Serebrovsky—do not appear at all.

This inequality in the opposing forces and the absence of geneticists was not true in the skirmish of 1936 or the full dress battle of 1939. Then geneticists appeared in force and not only in defense but in attack. That the ranks of one side have dwindled to so few is one way of describing what has happened.

What now was the question at issue in this unequal debate? Ostensibly it was the inheritance of direct effects of the environment, the doctrine of Michurin, carefully dissociated from Lamarckism (for Lamarck was a foreigner) versus Weismannism, which the attackers define as the belief in an immortal and sacrosanct hereditary substance, the germ plasm insulated from all modification by the environment, and thus rendering impossible the inheritance of environmental effects. Actually the question was this: Shall two doctrines, one the "Michurin trend," and the other the "Weismann trend," be permitted to exist and to compete in the Soviet Union? The opposition thought they could, but only Rapoport and Schmalhausen came out wholeheartedly for this position. Brave words were spoken by Zhukovsky in criticism of Lysenko, but in the end, after Lysenko revealed that his address had had the prior approval of the Central Committee of the Communist Party, Zhukovsky, Alikhanian, and Polyakov recanted to remove what traces of heresy still clung to their names. It was not only this act but also the political slogans throughout the speeches and the continued reference to the highest scientific authorities as being Marx, Engels, Lenin, and Stalin which so clearly show that these men are Communists first and scientists second. They would probably say that they are first of all Soviet Citizens with a first duty to the state. This is a choice and an order that may seem both unnecessary and "unnatural" to those who have never, or not yet, faced the hard necessities of life on the margins of subsistence and of national existence in a hostile world. Again we report what seems to be a fact and refrain from judgment.

As we read these pages, some of which sound like excerpts torn from a Chekov comedy, we realize that these men are more than Soviet citizens: they are also Russians. The scene of their struggle is the Soviet Union of 1948, to be sure, but this is one political scene superimposed upon the ancient culture of Russia. Here are still the chiefs and elders making obeisance, but now to Joseph Vissarionovich Stalin; and the tribal gods from whom he derives his authority are Marx and Lenin.

The decision on the question was clear enough. Lysenko and his supporters won a complete victory. Perhaps it would be better to say that they had already won it before the debate was convened to make the triumph public. The winners were the agricultural politicians, but the losers were not merely the handful of geneticists who appeared to defend (and to expose) themselves. Lost also were scientific integrity, freedom of thought and speech, sober detachment and impartiality before the facts of nature, all elements of the soil and climate in which modern science has grown.

There is some internal evidence in these speeches as to why the controversy broke out in the U. S. S. R. and at this particular time, but there is no room in an already over-long review to examine this question. Suffice it to say that the reasons appear to be political and social; they can only be said to be scientific in so far as the whole attack on genetics seems to rest on ignorance, which in some cases appears to be willful ignorance, of the evidence, the methods, and the principles of modern genetics.

L. C. Dunn

THE HUMAN RACE. *A Study in the Nature of Knowledge.*

By Emil Froeschels. Philosophical Library, New York. $3.00. 197 pp. 1947.

This book is a philosopher's approach to the relationship between philosophy and medicine, and is an expansion of lectures given by the author over a period of years in the Medical School of the University of Vienna. The book is in three parts entitled: Congenital Knowledge, Two Different Kinds of Time, and Our Destiny.

In Part I, that dealing with congenital knowledge, Froeschels has considered the knowledge of the infinite in mathematics and in philosophy, the existence of God as a variety of the infinite, and the "unconscious" and its antithesis, the conscious, which he reduces to new terms, namely, "the non-expression-ripe" and "the expression-ripe." He describes the relation of the non-expression-ripe to the expression-ripe in perception, action, understanding, the arts, neuropathological symptoms, witticism, and so on. In these new terms, he approachs the Meyerian term of "more or less conscious" and gets closer to Hartmann's conceptions of the unconscious. He asserts that everything we understand can be understood only as a member of an antithetical pair: finite—infinite, for instance. Just how the material understood as congenital knowledge comes to be such is not clear to this reader.

In Part II there are chapters on Time; Motion and Rest, The Present Tense—Being and Becoming, Concepts and Their Essential Relations to Time; The Will, Causalism, Conditionalism, Similarity; Causalism and Conditionalism in Medicine; Freedom of Choice; Psychogenesis—The Body-Soul-Question; Reason and Will; and Reality and Truth. The most interesting item in this part of the book is his conception of the will as "the prototype of force that makes us feel the causes of change everywhere including those which are called forces in physics, e.g. the force of gravity... causality is the projection of our will into the outer world.... Since this property of causality, the flow, (of a preceding phenomenon into a following one) belongs to the realm of motion and since a concept of motion does not exist, causality cannot possibly be a form of thinking." He summarizes this by saying: "Causality is a 'category' of our will-power and not a form of our thinking." He insists that the expressions "stronger motives" and "weaker motives" are incorrectly used, and he holds that motives of equal strength are never present within the range of will; in fact, there is not any system of measure within the scope of the will. "It is the sovereignty of the will, the freedom of choice that accounts for the fact that finally one motive is chosen." He looks upon repression in the psychoanalytic sense as an active process, namely, "as a desire not to bring certain conflicts to consciousness. The will may avoid certain concepts and they therefore may not become expression-ripe."

In the final chapter of the book, upon Life After Death, the author states: "The soul which is congenitally endowed with the knowledge of God, of the infinite, and of the universe can hardly be thought of as mortal, because the finite can not have any knowledge of the infinite. Only something that has 'sufficient space for the infinite' can know it." He states that all monotheistic religions insist that man's welfare on earth "should be subordinated to man's communion with God.... Our desire for well-being on earth is not the ultimate goal.... If the will raises knowledge to expression-ripeness in sovereign freedom, then there is no place for resignation to a determinism or decline. The hope must always remain that men, who are equal participants in the community of infinite knowledge, may become aware of this community, act in accordance with infinite values, and discard the more obvious finite elements whose essence is division and whose effect may be discord."

It expresses something concerning our American concept of medical education that such a series of lectures would be practically unknown in any medical school that the reviewer is aware of. We have become technicians in a very strict sense, and our desire to join others, particularly philosophers, in a discussion of "what it is all about" is at a low ebb. Something of the present sort might very well be considered as binding material in working with the over-all social problem.

WENDELL MUNCIE

◆

NEW DIRECTIONS IN SCIENCE TEACHING. *A Report of a Cooperative Project in Seventeen Secondary Schools with the Bureau of Educational Research in Science Teachers College, Columbia University.*

By Anita Duncan Laton and Samuel Ralph Powers. McGraw-Hill Book Company, New York, Toronto and London. $2.50. xii + 164 pp. 1949.

This book describes in detail a long-term and extensive project aimed at introducing new procedures and emphases in science into the actual science classroom. These new procedures and emphases aim to lead science students "to a clearer understanding of society, of the social function of science, and of their individual needs and interests." The reports of the experiences of teachers and students in the 17 participating schools are of a specific nature, and reveal new methods and new aims by describing actual work in progress rather than by abstract generalizing.

Several "new directions in science teaching" are described, all of which center around the human being and his relation to his world. Studies of the community, studies of young people, studies of current problems, courses emphasizing human development and growth, studies of man's relation to the natural resources, in particular those of his own region, all these reveal the increased value of science courses when the emphasis is placed on the individual human being and his relation to his world.

One important trend in science teaching is presented in the chapter on New Interdepartmental Courses. Progressive teachers are aware of the impossibility of staying within the rigid limits of one science, if the course is being taught for the sake of the students, and not for the sake of a traditional science. How can any student understand photosynthesis or digestion or any other life process without some knowledge of chemistry and physics? This growing tendency to break through traditional compartments of knowledge to an integration of knowledge from many fields is encouraging and should grow rapidly. *New Directions in Science Teaching* reports on several integrations: 1) Integration of all Subjects in the Ninth Grade; 2) Integration of Science and Social Studies; 3) Integration of American History and Chemistry; 4) Science and English; 5) Core Course on Human Living; and several more, all of which are worth serious study. This book should be of value to all science teachers and supervisors and to school administrators in helping them to plan and direct their science courses into channels which will touch the student's daily living, not only while he is in school but throughout his life.

ELLA THEA SMITH

◆

DIX PRÉLUDES À LA BIOLOGIE. *Sciences et Médecine, Série des Sciences Naturelles.*

By Robert Matthey. F. Rouge & Cie., Lausanne. 225 fr. (paper). 226 pp.; ill. 1945.

The ten topics considered in this series of discourses include the following: heredity; sex determination; twins; parthenogenesis; embryology; vision and orientation in bees; psychology of the vertebrates; psychology of reproduction in birds; the origin and uniqueness of man. These nine subjects are preceded by an introductory essay on biology in general. The purpose in presenting this work was to provide some scientific information to the general reader. As the author acknowledges in his preface, in order to achieve this end he has had to simplify to an extreme. No one versed in any of these fields should be too critical, since it was not written for him.

We do not believe that the mechanisms of heredity are so simple that a non-biologist can absorb and understand them at first glance, but assuming this hurdle leaped, then the essays on linkage and crossing over should prove interesting. The chapter on parthenogenesis is a good one, especially since the author's own cytological work on the orthopteran, *Saga pedo*, forms a large part of the material. Other chapters are on the whole based primarily on the work of other men, e.g., Frisch on bee orientation, Hediger on vertebrate psychology, Heinroth on bird psychology. In the final chapter, Matthey broaches his own ideas on man's relationship to other anthropoids. The point emphasized in this connection is that external differences in morphology are secondary to those of the nervous system, thereby giving rise to a wide hiatus in mental abilities.

HENRI C. SEIBERT

◆

PAGEANT OF LIFE SCIENCE. *Fourth Edition.*

By M. W. de Laubenfels. Prentice-Hall, New York. $5.95; $4.60 (textbook edition). vi + 407 pp.; ill. 1949.

With the present edition, this unusual and eye-catching biology text has graduated from offset reproduction of typewritten copy to standard printing on better paper. The improved contrast from the coated stock and glossy ink has helped many of the illustrations, but some of the photographs show less gain than would have been expected. Careful comparison with the third edition reveals small changes in the text, and added or substituted bibliographic references after the 28 chapters. Warnings about poison ivy are more vigorous, and the discussion on medicine has been extended to include the sulfa drugs as well as penicillin. There is a new chapter on phytophysiology and another on agriculture, with a clear conservation viewpoint. *Neurospora* and the recent South African advances in anthropology have not entered the respective chapters, but a few of the newer concepts achieve a place in this fresh edition. The three final chapters (Paleontology; Anthropology; Philosophy—Evolution, and Some Non-Biological Comments) show the same pronounced bias as in earlier editions. The sequence of, evidence for, and dispute over evolution are presented so briefly and in such argumentative style that students are likely to be led contrary to recent thinking on these subjects. The index has been simplified of its previous decimal notation, and though less precise, will require fewer rereadings of the explanation of symbols for occasional users.

LORUS J. & MARGERY J. MILNE

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BIOLOGY: HISTORY AND BIOGRAPHY

THE WORLD AS I SEE IT.

By Albert Einstein; translated by Alan Harris. Philosophical Library, New York. $2.75. xiv + 112 pp. 1949.

This interesting selection of addresses, letters, and writings by Albert Einstein is composed of material that dates for the most part from the period between World War I and the Nazification of Germany. Much of the book is devoted to simple and candid discussions of politics and pacifism, good and evil, the individual and society, and finally the status of the Jews. The book is the authorized English translation of the volume *Mein Weltbild.* Certain essays on relativity and cognate subjects have been omitted, and a correspondence with the Prussian Academy of Sciences, on the occasion of Einstein's resignation in 1933, is here published for the first time in its authentic and complete form. Although the political material is largely derived from the period after World War I, it is clearly if ironically relevant to the present.

The book should be of wide general interest. Its ideas are not those of an impractical but learned scholar, detached from the general struggle for the high ideals espoused. On the contrary, the author's familiarity with the practical complexities of the problems he deals with has evidently been established by many years of thoughtful concern for peace and the amelioration of the lot of the common man throughout the world.

Einstein speaks as the embodiment of 20th century man's conscience, and his unassuming formulation of clear, uncompromising truth should give courage to all men of good will. The quality of the book can be epitomized in the following excerpts, although they do not do justice to its poetry of spirit, its subtle discernment, its flashes of humor, its wide variety of themes, and its love of justice and reason, which make the reading of this book a great and refreshing experience.

"A hundred times every day I remind myself that my inner and outer life depend on the labours of other men, living and dead, and that I must exert myself in order to give in the same measure as I have received and am still receiving....

"The passions of nationalism have destroyed the community of the intellect.... The men of learning have become the chief mouthpieces of national tradition and have lost their sense of an intellectual commonwealth.

"The course of events in the last few years has once more shown us how little we are justified in leaving the struggle against armaments and against the war spirit to the governments.... The destiny of civilized humanity depends more than ever on the moral forces it is capable of generating....

"Most objects are gained by gradual steps: for example, the supersession of absolute monarchy by democracy. On the question of disarmament, however, we are concerned with an objective which cannot be reached step by step.... People will not disarm step by step, they will disarm at one blow or not at all... Disarmament and security are only to be had in combination. The one guarantee of security is an undertaking by all nations to give effect to the decisions of the international authority....

"We cannot despair of humanity, since we are ourselves human beings.... It is not the individual spectator's duty merely to wait and criticize. He must serve the cause by all means in his power. The fate of the world will be such as the world deserves."

The whole book cannot, unfortunately, be quoted here, but it can be recommended as imperative reading for every adult who flatters himself on possessing both a heart and a brain, and not simply a vertebral column.

Evelyn Howard

◆

Zwischen Anden und Atlantik. *Reisen eines Biologen in Südamerika.*

By Hans Krieg. Carl Hanser, München. 24.80 DM. 492 pp. + 35 plates; text ill. 1948.

The author, who is director of the Zoologische Staatssammlung in Munich, belongs to that nowadays all too small group of well-informed, enthusiastic naturalists who can extract from any environment a wealth of new and interesting information. During four trips to South America, lasting together nearly 8 years, he collected chiefly mammals and birds, and studied the wild and domesticated fauna, the human populations, and their relations to each other and to their varied habitats. The valuable scientific results of his material and data have already appeared in numerous technical publications. In the present volume, finished in 1939 but only printed 9 years later, the author has recorded his experiences in and impressions of the subtropical regions of South America in an informal, highly informative, and most readable manner. The many chapters represent actually more or less independent essays on the land and its life, particularly on many different mammals and birds, some reptiles and amphibians, the Indians and other human inhabitants, and on economic and political conditions in Latin America. The 347 admirable drawings and the 4 excellent reproductions of watercolors by the author are proof that Hans Krieg is not only a gifted writer, but also a very talented artist.

This book is a valuable addition to the many older, great works on South America by famous naturalists. Unfortunately it contains only an index of names, and lacks one of subjects in a broader sense.

A. H. Schultz

◆

Explorer of the Human Brain. *The Life of Santiago Ramón y Cajal (1852–1934).*

By Dorothy F. Cannon; with a memoir of Dr. Cajal by Sir Charles Sherrington. Henry Schuman, New York. $4.00. xvi + 303 pp. + 3 plates; text ill. 1949.

The series of biographies of which this volume forms a part presents to the layman the lives, aspirations, and accomplishments of great men of science. In writing of the life of the foremost investigator of the structure of nervous tissues, Dr. Dorothy Cannon finds herself in the interesting position of being the biographer of a biographically minded scientist. Cajal, perhaps, differed from other histologists of the nervous system in that he engaged in a consuming study of the whole nervous system in all of its complexity, and in an equally intensive effort to describe his exciting new findings to the biological world. Several hundred publications, including his autobiography, came from his pen, but they were all part of the same narrative, the life of the nervous tissue. His flair as a biographer is well described by Sir Charles Sherrington, who developed the basic modern concepts of the physiology of the nervous system with the help of the anatomical foundation largely laid by Cajal. Sherrington remarks, in an introductory memoir of Cajal in this volume: "Listening to him I asked myself how far this capacity for anthropomorphizing might not contribute to his success as an investigator. I never met anyone else in whom it was so marked."

Conspicuous in Cajal's approach to his work is not only a great curiosity and zeal for understanding, and the gift of seeing the whole purpose of his work in the midst of complex details, but also an intense personal motivation linked to an unusually passionate patriotism. Clearly depicted by Dorothy Cannon, within the texture of Cajal's personal development, are his outstanding contributions to the body of science: the development of the concept of the polarity and individuality of nerve cells, the elucidation of many details of the architectural superstructure of neuronal patterns and interneuronal relationships, the original histological techniques, and the development of students who became masters in their own right.

In the phenomenon of greatness, the evaluation of time and place is certainly second only to the capacity of the man. Lacking in this story of a man's contribution to neurology is the historical retrospect which might indicate the soil from which Cajal's rich harvest sprang. In a short biography this defect can readily be excused.

David Bodian

* * *

Naturalists of the Frontier. *Second Edition.*
By Samuel Wood Geiser. Southern Methodist University, Dallas. $5.00. 296 pp.; ill. 1948.

As this reviewer well knows from his own friends among pioneer naturalists on scientific frontiers in other parts of the world, these factual and sympathetically written biographies reveal the appalling difficulties under which Jacob Boll, Jean Louis Berlandier, Thomas Drummond, Audubon, Louis Cachand Ervendberg, Ferdinand Jakob Lindheimer, Ferdinand Roemer, Charles Wright, Gideon Lincecum, Julien Reverchon, and Gustaf Wilhelm Belgrage struggled to extend the frontiers of knowledge in Texas between 1820 and 1880. These very human documents reveal the frailty as well as the nobility of human nature, for it is on the frontier that such characteristics are more conspicuous. Considering the circumstances, it is no wonder that some of these naturalists did not accomplish much; it is amazing that so many achieved as much as they did. This is a book which cannot be overlooked by anyone interested in the development of science in the southwestern states. In an appendix, the author sets out chapter by chapter the principal sources from which he has drawn his material. He has also presented a relatively long, though admittedly incomplete, list of naturalists and collectors in Texas during the period 1820 to 1880. Included are certain names which he considers scientific hoaxes, and a partial list of the author's own publications on the history of science in early Texas. The makeup and printing of this book are attractive. The big page numbers are excellent, but one could wish for less hidden running heads and a larger general map of Texas, even at the expense of its taking the place of the striking end papers. The use of individual maps to show the activities of the several authors is excellent.

Robert L. Pendleton

* * *

The Story of Medicine.
By Joseph Garland; illustrated by Erwin H. Austin. Houghton Mifflin Company, Boston. $2.75. x + 259 pp.; ill. 1949.

The story of man's attempt through the ages to understand, and so to prevent or cure his own bodily ailments is a truly romantic tale, filled with just as much human interest, drama, and suspense as any modern fictional thriller. The added interest and clarity which the author has given the story in this particular volume make it a thoroughly fascinating book. Written in an authoritative, yet simple manner, the work should have a strong appeal for the adolescent or young adult for whom it is primarily intended.

As a history of medicine, the volume is not a mere chronicle of names, dates, and events, but is rather an account of the surging power of awakening knowledge in its struggle against the superstition, the empiricism, the skepticism, and the pure ignorance which surrounded and encumbered the field of medical thought and action for so many centuries of the past. From its beginnings in the mysterious incantations and activities of the prehistoric medicine men, the story of the development of medicine is traced through the ancient civilizations of the world, with descriptions of the contributions of the Egyptians, Syrians, Babylonians, Persians, Hindus, Hebrews, Chinese, Greeks, and Romans, up to the "Dark Ages" when all learning was entombed in the monasteries. With the Renaissance individual thought and action reawakened in the field of medicine, as in many other fields of knowledge and endeavor. Clearly depicted are the tremendous accomplishments in medicine and surgery over the past one hundred years, following the advent of anesthesia and asepsis. With the present broadened knowledge of medicine and surgery that has resulted from research and clinical experience over the past fifty years, the outlook for the future is so bright as to be beyond our present powers of imagination. With the reduction of deaths from the greatest killers of the past and the consequent aging of the population, new and different medical problems will face our future generations of doctors. With a shifting of emphasis from the curing of disease to the prevention of illness and the maintenance of health, our present generation is seeing a change in the character and responsibility of medical practice. In an age of medical specialization, the author concludes his treatise with a timely salute and a word of sympathetic understanding for the very back-bone of the profession—the general practitioner. The text is provided with an ample supply of line drawings, a bibliography, and an index.

B. Aubrey Schneider

Noah Webster: Letters on Yellow Fever Addressed to Dr. William Currie. *Supplements to the Bulletin of the History of Medicine, Number 9.*

Edited by Henry E. Sigerist, with an introductory essay by Benjamin Spector. The Johns Hopkins Press, Baltimore. $2.00 (paper). vi + 110 pp. + 1 plate. 1947.

No history of medicine in the United States would be complete without paying tribute to the accomplishments of a long and illustrious list of men, who, although they were not physicians, yet made notable contributions to the development of medical thought and practice. Among these men, Noah Webster has earned a place of distinction. Conducting his investigation and writing at a time when the whole medical profession was rigidly bound to the prevailing systems of medical thought and practice, and blinded by them, Webster was deliberate and caustic in his criticism of the profession's inability to grasp new concepts based on carefully collected evidence. He was equally deliberate, yet altruistically earnest, in emphasizing the need for informing the public on matters of public health.

Some 25 letters on Yellow Fever which Webster addressed to Dr. William Currie have been assembled in this volume, and are published for the first time since their original appearance in 1797 in the *New York Commercial Advertiser*. Throughout the letters, one is impressed by Webster's keen ability to collect and analyse facts relating to the specific concepts and theories which he propounded. For example, Letter IV (November 1) opens thus: "To prove that the plague, though infectious, does not depend on specific contagion for propagation, but on accidental and local circumstances, let me call your attention to facts." Webster then proceeds to marshal the evidence relating to the origin of the yellow fever plagues, their spread, and their limitations with regard to northern and southern latitudes, topography, rivers, mountains, and coastlines, as well as to the distribution of populations. By sheer force of incontestible evidence, the writer showed that yellow fever is related to latitude (being more prevalent in the warmer climates); that it is related to topography (being more prevalent in seashore and river lowland regions than in arid or mountainous regions); and that it is not spread, like other contagions, by contact of person to person. These letters are thoroughly enjoyable and enlightening to read, and can well be studied as patterns of investigation and presentation by the epidemiologists of today.

B. Aubrey Schneider

The New York Academy of Medicine: *Its First Hundred Years.*

By Philip Van Ingen. Columbia University Press, New York. $10.00. xii + 573 pp. + 24 plates. 1949.

Through its admirable medical library, the second in the United States, its Bulletin, and its Public Health and educational activities the New York Academy of Medicine, founded in 1847 as an association of 185 New York physicians, has indeed become a "national institution." The growth of the Academy was strong and steady, like that of the nation, the city, and the profession that fostered it. In 1874 it acquired its first home, in 1890 it built a second, and in 1926 it moved into its present luxurious quarters. It is interesting to notice that the latter development was primarily financed by the Carnegie and Rockefeller foundations. In entering this last stage of very extensive activities, the Academy was no longer able to carry on exclusively with elected officers, and has since, like similar organizations, acquired a quite sizable bureaucracy.

Unlike European Academies, the New York Academy was founded primarily not as a scientific body but as a professional combat organization, to fight especially against organized medicine's bugbear of the period, homeopathy. Only gradually, especially since the 1860's, has it grown into its present primarily scientific role. It is consistent with medical developments in the United States in general that during the 19th century the best work presented to the Academy was surgical. In the 1880's the events during the crisis over the Codes of Ethics of the A.M.A. and of the New York State Medical Society convinced the majority of fellows of the Academy that it would be best to keep out of medical politics in the future. In this instance, as in the whole history of the Academy up to 1919, the influence of Abraham Jacobi, the '48er who became the "father of American pediatrics" and belonged to the Academy for more than 60 years, was strongly felt. Public health is an interest which the Academy has followed without deviation from the very beginning. A survey of the discussions and problems of the 1920's arouses here as elsewhere a melancholic feeling that in some respects we have been turning in circles during the last 30 years.

The conscientious chronicle of Philip Van Ingen contains innumerable details that are of the greatest interest to a medical historian. Its purely descriptive form, which enumerates events in chronological order, is unfortunately such that it raises a doubt whether the book will be much read outside of a rather narrow circle of specialists.

ERWIN H. ACKERKNECHT

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READINGS IN THE HISTORY OF PSYCHOLOGY. *The Century Psychology Series.*

Compiled and edited by Wayne Dennis. Appleton-Century-Crofts, New York. $4.75. xii + 587 pp.; ill. 1948.

This compilation of readings in the history of psychology fills a long-standing gap in the library of psychological texts. It is the only such set available and, fortunately, it is a good selection. The volume contains 61 passages; 50 different authors are represented. With the exception of two from Aristotle, the selections cover the period from 1638 to 1930. Eighteen of the passages were originally published in the present century. Although the readings are of general interest, they are perhaps over weighted with materials from the field of general experimental psychology. All in all, this should be a valuable supplementary textbook for courses in historical and systematic psychology.

A. CHAPANIS

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A HISTORY OF AGRICULTURE.

By T. Bedford Franklin. G. Bell and Sons, London. 10s. 6d. viii + 239 pp.; ill. 1948.

While this book attempts to cover the history of agriculture from Old Testament times, the most significant, most interesting, and by far the largest part of the book covers the development of farming in Britain. The author comes from an old English rural family and evidently is well acquainted at first-hand with agriculture in England. Not only is his description of the historical development of agriculture in England highly interesting, but it is significant for an adequate understanding of the present plight in which Britain finds herself. The book is well written, beautifully printed and illustrated, and should be read by all Americans interested in the problems of land utilization, particularly those in that part of the United States east of the Mississippi River. The British price is cheap enough so that it should be available here at a reasonable price. Too many British books these days are priced too high for purchase by the average technical reader.

ROBERT L. PENDLETON

ECOLOGY AND NATURAL HISTORY

THE STUDY OF PLANT COMMUNITIES. *An Introduction to Plant Ecology.*

By Henry J. Oosting. W. H. Freeman and Company, San Francisco. $4.50. 389 pp. 1948.

Professor Oosting, of Duke University, writes from a sound background of training, teaching, and research. Like most busy men, he has learned to express himself simply, clearly, and directly. In consequence, he has produced, not merely a learned compilation, but a functional book, of which he might honestly say, "All of which I saw and part of which I was."

The book begins with a brief analysis of the nature of ecology, then considers at some length the nature of the community and the ways of getting at its structure and composition. A third group of chapters deals with the environment, a fourth with the processes of the community, and a final section deals with applied ecology. The illustrations are numerous and excellent, the discussion well balanced, and the references are numerous and good enough to give a generous introduction to the whole subject.

This reviewer has elsewhere (*Ecology*, 30: 109. 1949) indicated a few matters of fundamental theory which deserve more attention than they get. This is actually more of a comment on the current state of ecological thought than a valid criticism of this valuable book. For students well grounded in anatomy and physiology it will serve as an adequate textbook. For others, it might well be combined with the revision of Cowles *Ecology*, or used in conjunction with Daubenmire's *Plants and Environment.*

PAUL B. SEARS

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THE SOIL AND THE SEA. *A Symposium.*

By Julian Huxley, Anthony Barnett, Sir John Boyd Orr, Brian Vesey-Fitzgerald, Winifred Brenchley, Richard Clements, Hugh B. Cott, George Smith, J. D. U. Ward, James Gray, J. A. Scott Watson, F. E. le Gros Clark, L. Harrison Matthews, Gordon Haskell, M. K. Schwitzer, David T. Gauld, D. P. Hopkins, C. M. Yonge, and H. C. Long; edited by Trevor I. Williams. Saturn Press, London. 10s. 6d. 242 pp.; ill. 1949.

While the subtitle of this book is "a symposium," actually it appears to be merely a compilation of articles from popular British magazines by well-known British scientists and writers. While many of the articles are stimulating and contain at least much interesting and at times useful information, there is lacking any sense of that unity which could be expected from the subtitle. The only original article appears to be the introduction by Trevor I. Williams. The other articles and authors are: Science and the Farmer (J. A. Scott Watson); The Scientists' Guide to Global Food (F. E. leGros Clark); Chemical Stimulants for Crops (Richard Clements); Weeds of Cornfields (Winifred E. Brenchley); Chemurgy—New Uses for Farm Crops (M. K. Schwitzer); Seeds and Civilization (Gordon Haskell); Crops without Soil (D. P. Hopkins); Forestry Today (Sir John Boyd Orr); Seeds of the Forest (J. D. U. Ward); The Influence of Man on Marine Life (C. M. Yonge); Whales and Whaling (L. Harrison Matthews); Artificial Fertilisers in Fish Farming (David T. Gauld); Species and Evolution (Julian S. Huxley); Migration of Vertebrate Animals (James Gray); The War against Rodents (Anthony Barnett); Fair Fowl and Foul Fare (Hugh B. Cott); The Senses of Bats (Brian Vesey-Fitzgerald); Moulds and Tropical Warfare (George Smith). One startling suggestion is that the sea should be fertilized in order to get more fish from it for human use. This is the opposite of suggestions of certain conservationists who hope that we can recover from the sea more of the essential elements which we need for fertilizing our land crops!

ROBERT L. PENDLETON

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DIAGNOSTIC TECHNIQUES FOR SOILS AND CROPS. *Their Value and Use in Estimating the Fertility Status of Soils and Nutritional Requirements of Crops.*

Edited by Herminie Broedel Kitchen; prepared by Firman E. Bear, Roger H. Bray, Leland F. Burkhart, Jackson B. Hester, Bert A. Krantz, James E. McMurtrey, Jr., Ivan E. Miles, Werner L. Nelson, Michael Peech, J. Fielding Reed, Albert Ulrich and Silvere C. Vandecaveye. The American Potash Institute, Washington, D. C. $2.00. xxiv + 308 pp.; ill. 1948.

Almost anyone concerned with the production of plants or estimating the plant-producing capacity of soils can read this book with profit, at least considerable portions of it. It sets out the real problems and difficulties of endeavoring to estimate even roughly the fertilizer or other needs of any one soil for any one crop. Each section has a lengthy bibliography. Bear has written an excellent historical introduction, giving the history of the understanding of plant nutrition and telling how various researchers have endeavored to estimate the fertilizer needs better. Peech gives a critical review of the chemical methods now in common use for assessing soil fertility. The underlying principles on which the methods are based, and the advantages and disadvantages of the methods, as well as their usefulness and limitations, are pointed out. Bray discusses the correlation of soil tests for crop response without fertilizers and with fertilizer requirements. With references to 14 of his own papers, this is an important statement of the position of the leading soil fertility scientist in Illinois. He concludes that plant tissue tests are the solution to nitrogen control and gives two methods in detail. Miles and Reed describe how the North Carolina soil testing service operates and give many useful practical hints. Hester discusses the operation of an industrial service laboratory for analysing soil and plant samples, namely, that of the department of agricultural research of the Campbell Soup Company. He emphasizes that soil fertility in successful crop production cannot be over-stressed and that quality in the products used is of paramount importance to a processing industry. Krantz, Nelson, and Burkhart discuss the use of plant tissue tests as a tool in agronomic research. They conclude that plant tissue tests are one of the many aids that can be used to determine how to obtain optimum plant performance in any given environment, and that tissue tests should supplement rather than replace other tests and measurements. They describe at length the testing procedure for plants at various stages of growth, and discuss applications and interpretations. Ulrich presents the concepts of critical nutrient levels within the plant, and the theory of "limiting factors." He gives the analytical methods used in his laboratory. Vandecaveye discusses biological methods of determining nutrients in soils, giving very useful comparisons on the lettuce and sunflower between Neubauer's soil-plaque method and Niklas' *Aspergillus niger* method. The laboratory techniques are set out in sufficient detail to enable them to be followed. His comparison of these with other methods is extremely useful. McMurtrey describes the visual symptoms of malnutrition in plants and presents some useful color plates of plants to show the effects of different deficiencies. This chapter includes a key to plant nutrient deficiency symptoms and an extensive review of the literature, element by element, summarizing visual deficiency symptoms of plants, and giving the botanical names of most of them making the review useful internationally. A bibliography of 175 references is incorporated in this review alone. No one who is concerned with crop production, particularly where fertilizers or other soil amendments are used, can afford to be without a copy of this well-edited and beautifully printed book at hand.

ROBERT L. PENDLETON

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LARGE WAS OUR BOUNTY: *Natural Resources and the Schools. 1948 Yearbook.*

Association for Supervision and Curriculum Development of the National Education Association, Washington, D. C. $2.50. 216 pp.; ill. 1948.

This is really a thrilling book and striking evidence of the dynamic attitude now taken by leaders of education. Its concern is with the development and use of our natural resources and with what schools are doing to make our use wiser. The chapter headings are: In What Direction Are We Moving?; Why Are We Concerned?; How Has Our Thinking Expanded?; What Principles Shall Guide Us?; What Are Schools Now Doing?; and How May We Move Ahead? An evidence of the openmindedness and progressiveness of the committee preparing this yearbook is the fact that they, professional educators, have dared to use even a little simplified spelling. To many of us the country school teacher typifies conservatism—she is the one who insists upon following the textbook, because it has always been just that way. Not only does this book attempt to show the teachers how to relate students to their particular world but also how they can better lead their communities toward better appreciation of the essential and limited character of natural resources, and hence why and how resources must be conserved. The book is well printed; the illustrations are excellent and to the point. The volume closes with a list of about 10,000 names and addresses of members of the Association.

ROBERT L. PENDLETON

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LIMNOLOGICAL ASPECTS OF WATER SUPPLY AND WASTE DISPOSAL. *Publication of the American Association for the Advancement of Science.*

Edited by F. R. Moulton and Florence Hitzel. American Association for the Advancement of Science, Washington, D. C. $3.25 (cloth); $2.75 (paper). vi + 87 pp.; ill. 1949.

This slender volume consists of eight papers by eleven authors, dealing with such subjects as stream pollution, sewage disposal, and the biological effects of algal control. Although the symposium was designed to focus on the common meeting-ground of the sanitary engineer and the hydrobiologist, it is, like all such efforts, spotty and incomplete. The most conspicuous gap is the lack of any discussion of the rationale of using our streams and tidal waters for the disposal of valuable materials which should be returned to the soil. A general statement of the biology of sewage plants would have made a good introduction. The most interesting papers for the biologist are those that deal with stream biota in relation to pollution. While these papers will be of interest and use to those concerned with the general problems of sewage disposal, the price seems a bit high for what is little more than an extended pamphlet.

JOEL W. HEDGPETH

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FIELD GUIDE FOR BIRDS, WILD FLOWERS AND NATURE STUDY. *Grosset's Library of Practical Handbooks.*

By Leon A. Hausman. Grosset & Dunlap Publishers, New York. $1.00. xii + 107 pp.; ill. 1948.

Although not intended as a field guide for children, the simplicity of treatment and lack of detailed information places this volume in the category of primers. Since its few pages cover not only the natural history sides of botany and zoology, aquatic as well as terrestrial, but also geology, mineralogy, astronomy, and cloud formation, together with 400 illustrations, a cursory treatment is inevitable. As a consequence, it can scarcely be considered a contribution to our natural history literature.

C. P. SWANSON

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THE NATURAL HISTORY OF MOSQUITOES.

By Marston Bates. The Macmillan Company, New York. $5.00. xvi + 379 pp. + 16 plates; text ill. 1949.

Marston Bates has assigned himself a very difficult task—to bring together in one volume an account of the natural history of nearly 2000 species of mosquitoes, widely distributed throughout the world. When one recalls the vast and complicated literature dealing with mosquito biology, bionomica, distribution, taxonomy, etc., the author is to be congratulated for his bravery in undertaking such a work. In the introductory chapter, he has outlined the problems before him and defined the objectives he had in mind. He has adopted the term Natural History "in order to emphasize a broad approach to a limited group of animals." He defines it as not only including the somewhat modern science of Ecology, but also the analytical work of the laboratory—in other words it "includes both the field and laboratory study of living organisms." "Field observations of the behavior of single organisms or of the interrelations of communities of organisms can hardly be interpreted without laboratory analysis under conditions where experimental techniques can be applied," states the author. In this book the author has attempted to restrict himself to the disciplines of ecology and physiology, though throughout the emphasis is mainly on behavior.

It is not possible to review adequately such a compendium of information as is gathered here from published works and the extensive experiences of the author in the field of mosquito biology. A brief listing of the chapters will give the best idea of its contents and the arrangement of the subject matter. The author begins his analysis with a study of the adult mosquito, devoting Chapters II to V to the various aspects of adult activities, such as environment, survival and dispersion, sexual behavior, and food habits.

Chapters VI and VII are devoted to the discussion of egg development in the female and the characteristic oviposition habits of mosquitoes in general, with brief accounts of the various types of eggs. Chapters VIII to XI are concerned with the larval stage, and stress such topics as environment, physiology and behavior, the biological characteristics of aquatic life, and finally, an attempt to classify larval habitats. The pupal stage is treated very briefly in Chapter XII, and the reviewer could wish a more detailed account had been given of the tremendous physiological activities which transform an aquatic larva into a delicate, wonderful mosquito within the space of two or more days. Chapters XIII to XV deal with the enemies of mosquitoes, and their relation to disease transmission to man or other animals (as transmission of viruses and plasmodia). In Chapter XVI, the author treads the delicate ground of the species problem and tries his hand at a solution of the mechanics of speciation, only to land, like most experts on speciation, in the doldrums of conjecture. In Chapter XVII there is a very sane and useful discussion of mosquito classification wherein the author, like the reviewer, deplores the vast number of described species that have had to be sunk into synonymy. Unfortunately, a good many of the so-called new species described within the past twenty years will probably have to be treated in the same manner. It would be well for our younger taxonomists to read and digest this chapter and to devote more of their energies to the study of Natural History, as defined by Bates.

There follow a discussion of the faunal distribution of mosquitoes, an account of the methods of mosquito study, and a welcome chapter on mosquito research. The author closes with a list of the various species of mosquitoes (201 species) mentioned in the text, an excellent bibliography, and an index.

Though the reviewer might point out some faults of omission or certain doubtful conclusions, it does not seem that such criticism would detract from the very valuable contributions of this work. The natural history of our northern mosquitoes of North America is treated very lightly, as might be expected, since the author's main research has been with anophelines and tropical species of mosquitoes. His viewpoint of the so-called *maculipennis* group of North America is that adopted by Aitken (1945), although Vargas and the reviewer have pointed out several times that the so-called *occidentalis* species of the East is a distinct species, both on morphological grounds and habits. Unfortunately, we have no authoritative distributional studies of the eastern species (*Anopheles earlei* Vargas) except that of the reviewer and that study extends west only to Michigan.

This work of Marston Bates should indeed be in the hands of all workers concerned with mosquito biology. That taxonomists should beware of loading the literature with new species about which little or nothing is known of the biology is a sound conclusion of the author.

ROBERT MATHESON

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THE BEE HUNTER.

By George Harold Edgell. Harvard University Press Cambridge. $2.50 49 pp.; ill. 1949.

As a successful bee hunter of fifty years' experience, G. H. Edgell, Director of Boston's Museum of Fine Arts, at length became sufficiently irritated with printed accounts of trailing wild bees to their tree hives that he drew together the present treatise. In some eleven thousand words he tells in detail and anecdote how to be successful at the art—with expert hunting, from forty-three minutes up to two years being needed to locate an individual bee tree! The "ostensible object is honey," but "it is the least of your rewards. The reward is when, after hours or days of trial and error, your eye catches the flash of wings in the tree and once more you are able to say checkmate in one of the most difficult, complicated, and fascinating games in the world."

The brevity of this informal, amusing lecture somehow brought to mind Ellis Parker Butler's *Pigs is Pigs.* Our copy of the latter is about the same physical size, also cloth bound—and cost us 25¢. Ten times that price seems high for three times the wordage. At $1.00, the art that Director Edgell extolls might have found more followers.

LORUS J. & MARGERY J. MILNE

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LIFE HISTORIES OF NORTH AMERICAN THRUSHES, KINGLETS, AND THEIR ALLIES. *Order Passeriformes, Smithsonian Institution, United States National Museum, Bulletin 196.*

By Arthur Cleveland Bent. Smithsonian Institution, Washington, D. C. $1.50 (paper). viii + 454 pp. + 51 plates. 1949.

This seventeenth volume in the series of life histories of North American birds includes two families, that of the thrushes (robin, bluebird, wheatear, wood thrush, etc.) and that of the kinglets (gnatcatchers and kinglets). The same method of treatment as in previous volumes is followed. One interesting feature of the present number is the inclusion of many species not commonly considered as North American birds, but appearing on the list because they are found, accidentally or otherwise, in such remote areas as Alaska and Greenland. Thus the Iceland red-winged thrush, the fieldfare, the European blackbird, the European wheatear, the red-spotted bluethroat, and Middendorff's grasshopper-warbler are included. These birds, however foreign they may appear to be, are accorded full treatment and are provided with the usual amount of information. For those not familiar with Bent's volumes, this information consists of: spring, nesting, eggs, incubation, young, plumages (of the young), food, behavior, voice, field marks, enemies, fall, winter, breeding range, winter range, migration, casual records, and egg dates. Some species have additional information about interesting banding records. The usual photographs and bibliography are present.

HENRI C. SEIBERT

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MAINE BIRDS. *Bulletin of the Museum of Comparative Zoölogy at Harvard College, Volume 102.*

By Ralph S. Palmer; based largely on data gathered by Arthur Herbert Norton. Museum of Comparative Zoölogy, Cambridge. $5.00. 656 pp.; maps. 1949.

Back in 1908 Ora Knight published the *Birds of Maine.* Since that date new information on Maine birds has accumulated in the literature, but hardly enough to have justified the present report had it not been for A. H. Norton, who, on his own, formed a file of some 17,500 cards containing 60,000 entries relating to Maine birds. Norton was so busy during his lifetime that he never contemplated publishing his material, but fortunately bequeathed the file to Palmer. The latter has incorporated these data in the present publication. To this have been added his own observations plus information gathered from a careful survey of the literature. As a result, not only has the ornithology of Maine been brought up to date, but many of the records have been evaluated as to their reliability, and many of the old errors exposed. A recapitulation indicates that 339 species and 22 additional subspecies are authentic birds of the state. This excludes hypothetical, introduced, extirpated, or erroneously recorded species.

No attempt has been made to offer an historical background of ornithological work in the state, nor any discussion of its physical or vegetational features. For each species the subject matter is subdivided into a) general status, b) spring, c) fall migration, d) flight years or incursions, d) breeding, f) winter status, g) ecology, h) remarks. In the last subdivision there are often interesting comments on population changes since Knight's time. (Naturally some species do not possess all these categories.) There is an index, along with three maps and a very extensive and apparently complete bibliography. Although there are large areas left in Maine where the bird life has never been studied, at least one can feel assured that the knowledge concerning what is known has been included in this report. Future workers in Maine can be thankful that a dependable reference is now available.

HENRI C. SEIBERT

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A STUDY OF A GROUP OF PENGUINS OF KNOWN AGE. *Biological Monographs, Number 1.*

By L. E. Richdale. Otago Daily Times and Witness Newspapers Company, Dunedin, New Zealand. 12s. 6d. (paper). viii + 88 pp. + 7 plates; text ill. 1949.

Because of their appealing and amusing appearance, penguins are well known to visitors of zoological gardens, but not well enough to the ornithologist. This latter deficiency has been reduced in great part by the persistent labors of the present writer, a resident of New Zealand where some of the penguins live. This particular monograph is based on 12 years observation of yellow-eyed penguins which were banded as nestlings or juveniles, and whose exact age was known. The writer succeeded in banding 460 young, and the data on these birds provide considerable information about the breeding and related behavior of this species.

It was found that there is a strong tendency for breeding birds to return to the same breeding place. Males tend to mate with females younger than themselves, and fertility among young birds, especially the males, is low. Eggs of two-year old females are lighter and narrower than those of three-year olds, which in turn are lighter and narrower than those of four-year olds, the maximum weight and length being attained in the fourth and fifth years. Clutch size is also smaller in younger birds. A tendency toward adolescent sterility was noted, since, out of 76 two-year old females, 48 per cent did not lay, 7 per cent did not complete incubation, and only 34 per cent of the eggs laid hatched. Among three-year old females laying for the first time, 67 per cent of the eggs laid hatched; among three-year olds laying for the second year, 83 per cent hatched; and among eggs laid by four-year olds, 91 per cent hatched. Only one case of inbreeding was discovered—two birds from the same clutch mated and reared chicks. Unemployed birds (here defined as a bird without eggs or chicks at a time when other birds are so employed; such a bird may earlier have possessed eggs or chicks, and hence differs from a non-breeder) from a large proportion of the penguin population, up to 61 per cent of the total adults.

These are but some of the results obtained in this valuable study. The pages are replete with tables (56 in all), each of which is ably explained. A general discussion at the end compares the breeding biology of the penguin with that of other species for which there is comparable information. Although limited in its scope to those penguins of known age, the amount of information extracted from the data speaks highly of the author's devotion through long hours in the field and of his astute powers of observation.

HENRI C. SEIBERT

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THE BIRDS OF CONCORD. *A Study in Population Trends. New England Bird Studies, II.*

By Ludlow Griscom. Harvard University Press, Cambridge. $5.00. xii + 340 pp. + 16 plates; text ill. 1949.

Here is something more than a mere compilation of a bird list from a selected region. Although 287 species and subspecies are recorded as having occurred in Concord, Assabat, and Sudbury River valleys of Massachusetts, this amazing total for a northeastern state is not the primary reason behind the publication of this book. Rather, it is a valuable comparison of the bird life, back to the 1860's, with that of today. Nowhere else has an avian population been analysed for a period extending some 80 years. This feat was made possible by the voluminous notes of William Brewster, whom the author considers to have been a field ornithologist without peer. Since Brewster's time others have worked the region regularly, with the result that a continuous record is available.

The introduction gives a detailed account of the source material upon which the succeeding discussion is based. The latter is divided into Part I, Population Trends, and Part II, Birds of the Concord Region. Part I considers basic factors, such as geology, climate, vegetation, and the effects of civilization. It is concluded that static populations for any length of time are impossible because of major and minor climatic cycles and attendant shifts of vegetation and food supply. Human civilization is considered a factor as important as any other except major climatic changes. Declines and increases are discussed next, and here the myth of periodic fluctuations is further punctured; the periodicity is merely a mathematical average which does not correspond with the facts. Crashes are due to a complicated pattern of various causes, from which the species affected normally recovers. Only when human interference is an added agent does the population decline last for a long period. The erratic status of many species is described in detail and analysed for the causes behind the shifts. Some are inexplicable at present, e.g., the decline of the indigo bunting and nighthawk. Others can be correlated with changes in vegetation or habitat, or to reduced hunting (egret) or loss of food supply (brant). The severe hurricane of 1938 destroyed most of the large trees, and its effect on tree-hole nesting birds is still being felt. Griscom feels that these are all minor or temporary changes and that, because of the adaptability of birds in general, the populations will return as soon as the unfavorable circumstances are ameliorated, provided of course, that somewhere there is an overflow population to provide a nucleus from which the species can spread.

The second part is concerned mostly with the present status of the bird fauna and includes statistical data on breeding birds. The systematic list follows. A bibliography, index, and photographs of birds are included.

This volume is the second in the series (*Birds of Nantucket* being the first). The discussion in the present volume is of a more general nature and is applicable to birds everywhere. Anyone interested in animal populations should read this report carefully. It affords an intelligent and reasonable interpretation of population dynamics that is probably applicable to many other groups of animals besides birds. The reader will thereafter be cautious in the use of terms like "periodic cycles," "disasters," "booms," or "abundant." It has been clearly demonstrated in the 80 years of this record that a species may increase or decrease twice, and even three times, so that a fluctuating population is *the* normal population, whatever the causes underlying that fluctuation may be. It had best be borne continually in mind, therefore, that there is no set base-line or norm for making comparisons.

HENRI C. SEIBERT

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MAMMALS OF LAKE TAHOE.

By Robert T. Orr; illustrated by George and Patritia Mattson. California Academy of Sciences, San Francisco. $4.00. xii + 127 pp.; ill. 1949.

This book, dedicated to the memory of the naturalist James Moffitt, realizes a prolonged ambition of the author to write about an area that he has known for many years. The realization of the wish has produced a fine book that satisfies its purpose not only of being valuable to the general reader who is interested in the Lake Tahoe area, but of being scientifically correct as well.

The life histories of the fifty-three Tahoe mammals included present a description of each animal, its general and local distribution, and pertinent information regarding its habits. Each animal is represented by an excellent, life-like sketch, accompanied in some instances by a figure of its tracks.

In addition to the life histories, special sections of the book give a brief history of the Tahoe area, a description of its general physical and ecological features, an explanation of the methods used in classifying mammals in general, and a very workable, convenient key to the mammals of the lake region. A topographical map of the Tahoe area is to be found inside the back cover; and a glossary and list of references complete a book that the reviewer recommends without reservation to all readers interested in the subject.

JOHN CUSHING

ANNALES BIOLOGIQUES. *Conseil Permanent International Pour l'Exploration de la Mer. Volume IV.*
Edited by H. Blegvad; with the assistance of Aa. J. C. Jensen. Andr. Fred. Høst & Fils, Copenhague. Kr. 18.00 (paper). 152 pp.; ill. 1947.

EVOLUTION

PRÉCIS DES DÉCOUVERTES SOMIOLOGIQUES.
By C. S. Rafinesque. Peter Smith, New York. $4.00. iv + 56 pp. [1814]; 1948.

"A reprint of one of Rafinesque's earlier attempts to establish a system of classification for both animals and plants." His feeling was for a natural rather than an artificial system and, as he believed that races, varieties, and even species were evolving rapidly, he tended to split his taxonomic groups as he thought nature was doing. In this work he described 110 new species of animals and 79 new species of plants. His descriptions were characteristically inconsequential and he was successfully ignored by his contemporaries. His work, however, must now be considered seriously, thanks primarily to the efforts of E. D. Merrill, who wrote a brief foreword to this reprint. As more of Rafinesque's rare works are made available in facsimile, it becomes easier for modern taxonomists to do justice to his remarkable, if erratic, contributions.

CONWAY ZIRKLE

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LES HOMMES FOSSILES. *Éléments de Paléontologie Humaine. Third Edition.*
By Marcellin Boule; revised by Henri V. Vallois. Masson et Cie., Paris. 1500 fr. (paper). xii + 587 pp.; ill. 1946.

The last previous edition of Marcellin Boule's well-known and valuable treatise on human paleontology appeared in 1923. The interval of 23 years has witnessed the discovery of a great many important primate fossils, both human and otherwise, notably in China, Java, and Africa. The consideration of this material has greatly enlarged the text. Unfortunately, Boule did not live to complete this new revision, having died in 1942. It is fortunate, however, that the task of completion passed into the able hands of Henri Vallois, another eminent French student of fossil man.

The book, however, remains that of Boule and is not at all of Vallois. For the latter has faithfully followed his predecessor's arrangement and presentation of material, and one still finds Boule's old interpretations throughout. That Vallois does not always agree with Boule is evident from the preface written by the former—thus, for example, he speaks of the fossil men of Mount Carmel and Kafzeh as forms intermediate between Neanderthal man and *Homo sapiens*, and of Solo man as a type intermediate between *Pithecanthropus* and Neanderthal man. In this he is in agreement with the late Franz Weidenreich. The text, however presents the old conclusions of Boule—that *Pithecanthropus* and Neanderthal man are the terminal representatives of distinct and extinct branches of the hominid stem. It remains for the future to determine which of these interpretations is nearer to the truth. A case can be made out for both.

As for the Australopithecines, Boule has not accepted the verdict of their discoverers that they are directly ancestral to man. He regarded this declaration as premature, and was also skeptical of the conclusion that these animals were erect bipeds. Although he regarded the Australopithecines as true anthropoid apes, he admitted that they are the most manlike yet discovered, being in certain characters intermediate between the Dryopithecines and modern man.

This edition represents Marcellin Boule's last will and testament, and it will be duly valued as such. As already noted, Vallois appears to have recognized this and consequently has resisted the temptation to add post mortem codicils. That he saw fit to complete the revision essentially as Boule would have done, the reviewer for one is grateful. But he would also be grateful for a yet newer edition, or perhaps a separate work, in which Vallois will permit himself the full expression of his own views.

WILLIAM L. STRAUS, JR.

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A NEW THEORY OF HUMAN EVOLUTION.
By Sir Arthur Keith. Philosophical Library, New York. $4.75. x + 451 pp. 1949.

Sir Arthur Keith, the author of *A New Theory of Human Evolution*, has long been distinguished as an anatomist and physical anthropologist. He has contributed prolifically and substantially in both these categories, and he has intrenched his authority by the success of his charming popularizations. Now in his 80's, he has once more given to the public a summation and revision of his ideas on the origin, evolution, and differentiation of mankind, subjects on which he has frequently written in the past.

It is impossible in a short review to set forth all the details of Sir Arthur's hypothetical edifice or to examine extensively the ramifications of even some of his leading ideas. I must, therefore, content myself with a summary exposition of his main theses and a brief appraisal of their validity. In so far as human evolution is concerned, Sir Arthur has combined current concepts on the significance of isolation and territoriality with his own version of psychological instincts deeply rooted in human nature. He envisages as a necessary condition in the primal (pre-agricultural) stage of human evolution a "myriad" of small inbreeding population units, isolated genetically, fixed in space over very long periods of time, bound internally by a "consciousness of kind" and fiercely competitive with adjoining groups. The psychological "bias" essential to maintain such conditions favorable for evolution is developed at great length and is ramified into morals (codes of amity and of enmity), patriotism, loyalty, leadership, allegiance, cooperativeness, hate, enmity, cruelty, resentment, and revenge. These psychological factors are regarded as basic qualities with which emergent man was equipped and which served an evolutionary purpose by isolating the original breeding groups from one another and thereby allowed superiority of genetic endowment to survive intact and to permit favorable mutations to be preserved and dispersed rapidly within the group. The psychological aspects are especially stressed, since they are used subsequently to account for various phases of race.

This conception, compounded in detail of sound observation and undemonstrated assumption, is far from being completely convincing. If one goes to the same sources that served Sir Arthur, it is possible to argue that isolation was not as generally characteristic of these small primal groups as he finds necessary for his hypothesis. The absorption of the women of a defeated group, wife-stealing from neighboring bands, slavery, and the exchange of women for political purposes are widespread among the primitive folk who also provide Sir Arthur with his contrary illustrations. Moreover, the distribution of gene frequencies strongly suggests a long history of interbreeding as well as inbreeding. The elaborate psychological apparatus which is developed here as an integral part of the mechanism that controls human evolution requires far more support before one can accept it entirely despite the cogency of some of its elements.

In the sections that deal with the fossil record of man's evolution, Sir Arthur has made a number of radical revisions of his earlier views. He considers Africa as the cradle of the humanoid stock, which he now thinks became differentiated from the anthropoid stem mainly by a process of foetalization. He regards the Dartians or Australopithicinae as the earliest forerunners of man and conceives of them as spreading throughout the Old World and subsequently undergoing local developments which have led to distinct geographic races of mankind. These basic geographic subdivisions are Caucasian, Sinasian, Indoasian, African, and Australasian. Curiously, however, he still clings to Piltdown Man. But since he has difficulty in deriving him from the Dartian base, he assumes that this fossil type of man had an origin from an orang-like stock, an assumption which has the aspect of a deus ex machina.

The final portion of the book is devoted to the origin of modern races, and the role of nationalism in race making. Present-day nationalism is seen as an outgrowth of the original small breeding bands, and as a focus for the same psychological characteristics that governed human evolution in the past. In this view, then, nations are the modern mechanisms by which evolution is advanced and races are created. As in the earlier sections, assumption is built upon assumption with bewildering ease, and contradictions plague the reader. I found, for example, that "race" was used in a variety of ways. When the author attempts to distinguish his concept of race (described as "passionate") from the conventional one corresponding to the generally accepted systematic usage, he produces a difference without a meaning. At one point, the Scots are described as a race distinct from other groups in the British Isles, yet elsewhere he admits that he cannot distinguish them physically from other Britons! Although inbreeding is a cornerstone of his conception, Sir Arthur himself produces from Scotch as well as from other national, and consequently, in his view, racial history, abundant evidence to prove that modern European nations are conglomerations of various strains revealing a vast amount of interbreeding. It is distinctly curious that the role of interbreeding should, therefore, have been so carefully ignored by him as a significant factor in human evolution, and in the genesis of racial differentiation.

HARRY L. SHAPIRO

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STRATIGRAPHY AND FAUNA OF THE AGUA SALADA GROUP, STATE OF FALCÓN, VENEZUELA. *The Geological Society of America Memoir 32.*

By H. H. Renz. The Geological Society of America, New York. $2.75. x + 219 pp. + 12 plates + 1 chart; text ill. 1948.

The fauna described is composed entirely of smaller (that is, ordinary) foraminifera of late Tertiary age, which are beautifully illustrated by pen-and-ink drawings, variously magnified from × 22.5 to × 49. In the taxonomic treatment Cushman's classification is followed, though genera are arranged in alphabetical order, and only in the ecologic treatment of geologically different faunules has Cushman's classification in families been followed. Out of 239 described and catalogued foraminiferans 4 are new, while 55 other species and varieties were previously described as new from the same localities by Cushman and the author.

Whenever more than one specimen of a species is illustrated, considerable variability of most species is at once evident, and thus a critical reader interested in the Foraminifera gains a broader mental concept of the species surpassing the elegant sketches of the specimen selected to typify them. The most complete data on the variability of the species are thus given for *Liebusella pozonensis*, *Marginulinopsis basispinosus*, *Robulus wallacei*, *R. suteri*, *R. nuttalli*, *Valvulina flexilis*, and other species which Cushman and Renz themselves established among the local fossils.

No consideration is given to dimorphism in any of the descriptions, and hence in this respect the work is behind the new trend in the biologic treatment of fossil foraminifera, a trend which is gradually gaining momentum. Aside from this, Renz's work has many good points. Information and discussion concerning ecologic, stratigraphic, and geographic aspects of each species are perhaps the most commendable and useful parts of the publication. The author rightfully emphasizes the necessity of an ecological approach in the comparative study of fossil and living foraminiferans, and he himself utilizes skilfully the available empirical and generalized data of foraminiferal (and other) ecology in modern seas.

M. K. Elias

GENETICS AND CYTOLOGY

Genetics in Swedish Forestry Practice.

By Bertil Lindquist. Svenska Skogsvardsforeningens Forlag, Stockholm; The Chronica Botanica Company, Waltham, Massachusetts. $3.50 (paper). 173 pp.; ill. 1948.

The application of genetic principles in forestry practice has made remarkable progress in Sweden during the past decade. This accomplishment is traceable in large measure to a unity of purpose resulting from a more or less amicable truce declared between the environmentalists, that is to say, the classical silviculturists, and the geneticists. To the advantage of Swedish forestry practice these opposing factions early realized that, quite as much as the organisms they discussed, they were in fact mutually interdependent and that in the broad sense their arguments attributing superior roles to the environment or to the genotype were meaningless.

It may be readily appreciated that the logical path of approach in a forest-tree improvement program is to take immediate steps to preserve from destruction the best of the wild extant genotypes in various ecotypic zones. With such gene reservoirs established, current local planting demands may be supplied with what may at least be considered to be the best of the wild stock available. In addition, and what is of greater ultimate importance, the perpetuation of such desirable gene combinations for future recombinations in breeding studies may be assured. It is in this initial phase of the application of genetic principles to forestry practice that Lindquist has been most active, and it is with this that his book is primarily concerned.

The numerous special problems introduced in tree breeding programs, due to the large unit size of the material involved, the long time between sexual and vegetative maturity of succeeding generations, and the consequent necessity for comparatively long-term progeny tests, have been adequately described by the author. It is indeed these very problems which have stimulated the intensive application of the idea that it is genetically and economically good sense to utilize phenotypically élite parental trees and stands as current seed sources and breeding stock while their genotypes are at the same time being assessed by long-term progeny tests.

Lindquist's discussions of the role of genetics in silviculture are tempered by reasonable and justifiable claims for its possible contributions. Silviculturists will be pleased to read that: "(one should) . . . not let the thought of heredity obscure the fact that environmental conditions generally are and will be the dominant factors for the development of high-grade lumber in our forests."

The book is well organized, and the material is presented in a non-technical manner designed to appeal to the forester who may be unfamiliar with genetic terminology. Numerous excellent half-tone photographs have been used to advantage. These are, in some instances, more provocative than the text. It is to be regretted that specific citations to the literature have not been made, although the contributions of various investigators are in a general way often mentioned.

The realistic approach of the Swedes to forest-tree genetics problems is especially worthy of note to American foresters; and if this book accomplished nothing more than further to encourage American silvicultural thought to recognize the possibilities of genetic variability below the level of the species in our own trees, it will have accomplished a most worthwhile objective.

Scott S. Pauley

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Haemofili i Danmark. *En Klinisk, Haematologisk og Arvebiologisk Undersøgelse af 63 Haemofilislaegter. With an English Summary. Opera ex Domo Biologiae Hereditariae Humanae Universitatis Hafniensis. Volume 6.*

By Mogens Andreassen. Ejnar Munksgaard, Copenhagen. Kr. 10.—(paper). 168 pp.; ill. 1943.

The author has reported here the results of a comprehensive study of the genetics of hemophilia as seen in Denmark. The clinical and laboratory bases for the diagnosis of hemophilia are discussed in a manner that gives confidence in the validity of the cases the author presents. By means of widespread medical inquiry, as complete a roster as possible was established of all cases of hemophilia which had occurred in Denmark in the immediate past. Information was obtained concerning a total of 205 hemophiliacs in 63 different families; 81 of the hemophiliacs were living at the time of the inquiry. The average age at death of hemophiliacs was estimated to be 18 years, about one-third that of normal males. The evidence for the sex-linked inheritance of hemophilia is discussed. In particular, it is shown that in this material among the male children of women who should be heterozygous for the hemophilia gene because their fathers had the disease, there are 21 normal and 18 hemophilic sons, excellent agreement with the expected 1:1 ratio. The frequency of hemophilia in the Danish population is estimated to be 0.00013. The fecundity of hemophiliacs is placed at 0.57 that of normal. From the foregoing figures the average frequency of mutation for hemophilia is estimated at 0.000019 per chromosome per generation. The weakest spot in this calculation is the estimate of the mean fertility of hemophiliacs, but even if some revision of this is made, the order of magnitude of the mutation rate will probably not be altered. The author found that 30 our of 31 mothers of hemophiliacs showed a definite prolongation of coagulation time, an extremely significant demonstration both from the standpoint of further studies of the population dynamics of hemophilia and also because of the practical problem of predicting where hemophilia may be expected to occur in any kindred. This is an excellent study.

James V. Neel

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The Etiology of Deaf-Mutism, *With Special Reference to Heredity. Opera Ex Domo Biologiae Hereditariae Humanae Universitatis Hafniensis. Volume 8.*
By Harold Lindenov. Ejnar Munksgaard, Copenhagen. Kr. 25.00 (paper.). 268 pp. 1945.

This monograph reports the results of a large-scale investigation into the heredity of deaf-mutism. The introductory chapters are devoted to a discussion of the etiology and differential diagnosis of acquired and "idiopathic" deaf-mutism, and an extensive review of the voluminous past work on the genetics of the "idiopathic" form of the disease. The author's own material is composed of (1) 32 families in which deaf-mutes occurred, and in which as many members as possible of the families were studied by the author personally, and (2) 480 unselected deaf-mutes who were examined and from whom a family history was obtained, but with no examination of relatives of the propositi. No objective clinical finding which would serve as a certain means of differentiating between "idiopathic" and acquired deaf-mutism could be discovered. A careful history is thus the most reliable means of making the differentiation, and even this is not infrequently inadequate. No physical peculiarities were discovered that distinguish the deaf from the hearing members of families. It is estimated that 45.5% of deaf-mutism in Denmark is "idiopathic" and probably hereditary, the reminder being acquired. There is no apparent sex predisposition to the disease. The hereditary disease appears to be of at least two types, a minority representing a "heredolabyrinthic deaf-mutism," and a majority representing an undifferentiated type which may be genetically complex (see below). Consanguinity of the parents was significantly increased in the parentage of the "idiopathic" deaf-mutes (9.7%) as compared with the acquired deaf-mutes (2.2%) and the normal population (2.1%). The author's own material is insufficient to determine the mode of heredity of the heredolabyrinthic type; in the literature it is usually described as a dominant. The familial distribution of the remaining idiopathic cases is consistent with simple recessivity. It was felt that the present data provide evidence for a familial predisposition to acquired deaf-mutism. The reviewer would hesitate to accept this finding as having a genetic significance. Retinitis pigmentosa was so frequently present in deaf-mutes that the association cannot be ascribed to chance, and is thought to be due to a particular recessive gene responsible for both deafness and retinal disease. There are thus probably at least three genetic types of "idiopathic" deaf-mutism. Possible eugenic procedures are discussed. This is a sound and thorough piece of work, documented in the extensive manner we have come to expect of publications from the University Institute of Human Genetics of Denmark.

James V. Neel

GENERAL AND SYSTEMATIC BOTANY

Allgemeine Botanik. *Ein Lehrbuch Auf Vergleichend-Biologisher Grundlage.*
By Phil. Wilhelm Troll. Ferdinand Enke, Stuttgart. DM 60.00 (cloth); 56.00 (paper). xviii + 749 pp.; ill. 1948.

For the beginner facing the exciting challenge of a career in botany, and confronted, too, with the double necessity of mastering an important foreign language and of acquiring the basic principles of his science, there is no better prescription than the persistent reading of a good German text. For many decades there was scarcely a question as to what this should be. The Bonn textbook, fathered by Strasburger and amplified by his later collaborators, had no rivals.

The modernization of American botanical teaching began with Charles E. Bessey's frank adaptation of Sachs, and was furthered in original fashion by the Chicago textbook. It is not generally known that one of the best of our current textbooks was the fruit of a long ambition to produce "an American Strasburger."

The motif of the Bonn text has been from the particular to the general, from the component to the organism. This is the method of research. It is the path of evolution. It seems eminently logical, if one accepts the Cell Theory as meaning that the whole is the product of its parts.

Meanwhile, however, two powerful influences have entered the scene. One is the Organismal Doctrine. The other is the modern psychology of learning, which insists on the importance of proceeding from the known and familiar to the unknown. American textbooks have for some time adjusted themselves to these new viewpoints. But the best of them, as sheer didactic, visual, and bookmaking performances, have never excelled and rarely approached the best of the continental works.

Now comes Troll's "General Botany," which appears to have, on a first reading, the excellence of the Bonn textbook, although a more restricted coverage, and which begins with the plant as a whole, later developing the details of its structure and behavior. I can imagine no more profitable possession for the beginning specialist, although I should not discourage him from having the most recent edition of Strasburger (mine is the 22nd) on his shelf as well.

PAUL B. SEARS

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BOTANY OF THE CANADIAN EASTERN ARCTIC. *Part Two. Thallophyta and Bryophyta. National Museum of Canada, Bulletin Number 97, Biological Series Number 26.*

Compiled and edited by Nicholas Polunin. National Museum of Canada, Mines and Geology Branch, Department of Mines and Resources, Ottawa. $1.00 (paper). vi + 573 pp. + 1 map; text ill. 1947.

This volume of over 500 pages is an authoritative account of the algae, fungi, lichens, mosses, and hepatics, based upon reliable published and unpublished reports and from recent collections of an immense region of the Canadian Arctic. The work on the various groups has all been done by well-known experts in their fields, and we have as a result a fairly complete flora, if not of the vast Canadian Eastern Arctic, comprising as it does nearly a million square miles, yet, as the General Editor, Polunin, has aptly pointed out, of the few areas from which collections have been made. In other words, we know considerably more now about the kinds of Thallophyta and Bryophyta and their distribution within the region than ever before.

The chapter on the algae, exclusive of diatoms and marine phytoplankton, was prepared by Roy M. Whelden. Here are listed 108 of the Cyanophyceae, 1 of the Heterokontae, 3 of the Chrysophyceae, 247 of the Chlorophyceae (184 of which are desmids), 3 of the Dinophyceae, 12 of the Phaeophyceae, and 9 of the Rhodophyceae. Included among these forms, which were predominantly from fresh water, are many new records of occurrence both for Canada and for the whole of North America. Each species name is accompanied by a citation, pertinent synonyms, comments, and general and Eastern Arctic occurrence. This same format is followed throughout the volume. Like all others, the chapter is prefaced by a general account of previous work which has been done on the group in the area.

The section on marine phytoplankton (121 species) was contributed by Gunnar Seidenfaden of Copenhagen, and that on fresh-water diatoms (192 species) by Robert Ross of the British Museum (Natural History). Of the 79 species of fungi carefully and critically studied by the late David H. Linder, six are new species. The section on lichens was prepared by the late Bernt Lynge of Oslo, and includes citations of 275 species. The mosses, second to the algae in number of species (304), were treated by W. C. Steere, and the Hepaticae (78 species) was done by N. Polunin himself. Without question, this volume will be of immense value to those working in the area and its publication, although delayed nearly ten years by the war, should stimulate research of a similar nature in the Arctic.

One cannot fail to be impressed by the numerous footnotes added chiefly by Polunin for all the groups treated. While in some instances these were necessitated by developments which occurred in the prolonged period between the time the manuscripts were received and the time of publication, in other cases they seem to be unwarranted intrusions by the General Editor on the conclusions and opinions of his collaborators. The end result is an aura of editorial meddling which detracts from the authoritative air such a volume should possess.

F. K. SPARROW

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DIE PILZE. *Grundzüge Ihrer Entwicklungsgeschichte und Morphologie. Lehrbücher und Monographien aus dem Gebiete der Exakten Wissenschaften 19. Reihe der Experimentellen Biologie. Band IV.*

By Ernst Gäumann. Verlag Birkhäuser, Basel. Sw. fr. 38.00 (cloth); Sw. fr. 34.00 (paper). 382 pp.; ill. 1949.

This excellent volume follows in the main the outline of the author's earlier and more extensive book, *Vergleichende Morphologie der Pilze.*

After a brief preface, which includes a schematic diagram of Gäumann's ideas on the phylogeny of the fungi, the first of the four classes (Archimycetes, Phycomycetes, Ascomycetes, Basidiomycetes) into which the fungi are grouped is discussed. All classes but this first one, the Archimycetes, follow the traditional interpretation of the main fungus classes.

In the Archimycetes we see once more, as in the previous treatise, organisms grouped together which possess, in contrast to "true fungi," a naked vegetative phase that is converted as a whole into a reproductive structure. The resulting aggregation contains fungi with posteriorly uniflagellate zoospores (the Olpidiaceae and Synchytriaceae), together with those with heterokont (the Plasmodiophorales) or with isokont zoospores (the Olpidiopsidaceae).

Each family is briefly characterized, and its asexual and sexual cycle described. Although certain pertinent biological features, such as parasitism, etc., are sometimes included, the strict limitation of the book to morphology has necessitated the omission of many interesting aspects of the fungi under discussion. Important genera are discussed, but no detailed taxonomic account beyond the level of the family has been attempted. Following the Basidiomycetes comes a very brief summary of the Fungi Imperfecti. The volume terminates with an alphabetical list, by authors, of the literature cited, and an index.

There are many outstanding features in Gäumann's book. It is first of all a thoroughly up to date, concise, treatise on the morphology of the fungi, done in clear, readable German. The newer literature has been carefully surveyed and appropriately utilized in connection with what has gone before. Missing are many of the outworn, well-nigh classic figures of 19th century mycology. These have been replaced by illustrations from more recent papers. The figures themselves are uniformly accurate, excellently executed, and pertinent. It is to be hoped that an accurate translation into English will not ere long be forthcoming.

F. K. SPARROW

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MOSSES OF GUATEMALA. *Fieldiana: Botany, Volume 25.*

By Edwin B. Bartram. Chicago Natural History Museum, Chicago. $4.00. vi + 442 pp.; ill. 1949.

Based largely on material collected on several expeditions made to Guatemala by staff members of the Chicago Natural History Museum (formerly the Field Museum), this book is essentially a manual for the identification of the moss flora so far known from that republic. The author, who has already published similar treatments of the mosses of the Hawaiian Islands and of the Philippine Islands, has provided descriptions and original illustrations of 519 species in 205 genera. Bryologists will find interest in such details as the full bibliographical citations, the reasonably full listing of synonymy, and the citation of Guatemalan specimens seen. The non-specialist will also be grateful for the keys to the genera of each family that has more than one genus, and for the keys to the species of each genus. The richness of the Guatemalan moss flora, with its 519 species, is most easily understood upon comparison with that of any of the United States, since no state, even the best known, has more than 400 species, and very few have as many as 300. Nevertheless, the author intimates that another 100 species of mosses still remain to be discovered in Guatemala. This surprising wealth of mosses in a republic no larger than Tennessee or Virginia is ascribed to the great range of altitudes from sea level to permanent snow, the enormous variation in climate, rainfall, and vegetation, and the availability of rich floras on both the north and the south.

The general biogeographer interested in the distribution of tropical plants will find data of basic phytogeographical significance in the introduction to this book and in the statements of the general geographic range of each species. The author recognizes three general groups of mosses, the lowland species of circum-Caribbean distribution, those species characteristic of the interior highlands, and the alpine species of the higher mountain summits, each group represented by its own special families. He then identifies several floristic elements and lists 26 species of a distinctly north temperate affinity, typical of the northern United States and Canada; 14 typical Andean species; 3 tropical Brazilian mosses representing 3 genera new to North America; 23 well-known Caribbean species, found principally in the eastern lowlands; 18 species of local mosses which extend north through Mexico to Arizona and New Mexico; and a smaller group of 6 species that extends into California. The author has anticipated some criticism that the moss flora of Guatemala is too little known to justify the preparation of a manual in this form, and explains that his work is explorative. In spite of the faults of any pioneer study of a new area, cheerfully acknowledged here by the author, this book provides the first useful approach to the moss flora of any restricted tropical American area.

WILLIAM C. STEERE

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THE NATIVE TREES OF FLORIDA.

By Erdman West and Lillian E. Arnold. University of Florida Press, Gainesville. $3.75 (cloth); $3.00 (paper). xx + 212 pp.; ill. 1948.

The native plants of Florida have long been of particular interest to American botanists. Perhaps the principal reason is the large number of species of tropical distribution which are confined in this country to the Florida Peninsula. Among these the arborescent species form a conspicuous element. The present work, by two botanists of the Florida Agricultural Experiment Station, is concerned with such species, but also covers all native trees, including those whose natural distribution embraces areas to the north of the state.

Following a short introduction which includes a useful county map of Florida showing distributional areas, there is an artificial key leading to generic or family groups. No key to species is included, but this will probably lead to few difficulties in identification because of the relatively small number of species in each keyed category. Each species is presented on a single page, which includes a line drawing of foliage and floral structures, in addition to paragraphs giving a description, distinguishing characters, and general comment—the latter consisting of a few concise remarks on the geographical and ecological range of the species in Florida, its uses, and other pertinent information. A list of references, a brief glossary, and an index complete the book. The volume is attractively bound and well printed. It should prove most useful to an increasing number of students of Florida plants—both amateur and professional.

Norman H. Giles, Jr.

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THE VALLEY OF FLOWERS.

By Frank S. Smythe. W. W. Norton & Company, New York. $5.00. 325 pp. + 16 plates; text ill. 1949.

The vastness and inaccessibility of the Himalayan mountains are enough to make any travelogue about them worth investigation. When spiced with botanical observations, as this book is, its value to the botanist and gardener is heightened by the fact that the Himalayas are as rich in floral species as any section of the globe. A goodly proportion of our well-known garden species are native there, even though but a small segment of the region has been adequately explored by plant collectors. A comparison of genera will also reveal the floral relationships of these mountains to those of the southeastern United States. These facts, however, are to be derived only incidentally from the chapters, for Smythe writes from the point of view of an amateur botanist, struck by the floral panorama as it shifts with altitude and with the seasons. Other than listing the species encountered, the scientific value of the book is slight. It will provide, however, an interesting evening's reading.

C. P. Swanson

ECONOMIC BOTANY

HUMUS AND THE FARMER.

By Friend Sykes. Rodale Press, Emmaus, Pennsylvania. $4.50. xxii + 392 pp.; ill. 1949.

The author is a successful English farmer who describes in considerable detail his farming practices on the Salisbury plain, Wiltshire, and his reasons for performing them. His delightfully naive style has not been spoiled by a ghost writer. On the other hand the book contains considerable correspondence, lecture comments, quotations, and other material which might well have been condensed. As the title would suggest, the author has devoted considerable space to discussing the making of composts and the importance of organic matter. He admits that with hand labor compost-making is prohibitively expensive on most, if not all, farms. He describes the mechanical contrivances which he has developed to reduce the amount of manual labor needed and so to make compost-making practicable on English farms. Being a devotee of the organic school, the author vents some very strong and at times unreasonable opinions against the use of commercial fertilizers. Furthermore, his lack of scientific training leads him to be hyper-critical of the fertilizer trade and its standards of doing business. This book is interesting in that it shows how a resourceful and courageous farmer can adapt his farming practices to local needs and conditions, with great benefit to himself; and this, rather than any scientific or technical suggestions that might be directly useful to Americans, is the principal value of the book to us. Because Sykes travelled in the United States during the height of the depression, his comparisons between British and American farming are hardly fair; yet he seems to be under the impression that such conditions as he saw still prevail in this country. Indeed, the book was actually written toward the end of the war, when British farming conditions and controls, and their results, were very different from those prevalent in the United States during the depression. Though the halftone illustrations are disappointing, the book is nicely printed. The Rodale Press deserves credit for making available to American readers such unusual books as this. The glossary of peculiarly English farming terms, foreign to the United States or with different meanings here, is inadequate for the American reader.

Robert L. Pendleton

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MAKE FRIENDS WITH YOUR LAND. *A Chemist Looks at Organiculture.*

By Leonard Wickenden; foreword by Joseph W. Frazer; illustrated by E. W. Bartlett. The Devin-Adair Company, New York. $2.50. x + 132 pp.; ill. 1949.

This small book presents the opinions and experiences of an amateur gardener and devotee of the cult of organiculture. The author claims that his main purpose is to demonstrate that organiculture is not based on black magic. At least he makes out a good case for the conservation of organic matter and its use in composts. In this he is undoubtedly justified, for there is no question but that as great a use of organic matter in all forms of gardening and agriculture as can be afforded is to be highly commended and encouraged. On the other hand, perhaps because the author is a chemist, his objections to the use of chemical fertilizers are weak. Yet more strangely, he does not seem to take very seriously the importance of minor elements in many soils and the necessity for applying them. While it is undoubtedly true that the use of metallic poisons against insect pests and for the control of plant diseases has led to the accumulation of serious quantities of poisonous substances in the soil, it is difficult to believe with the author that the generous application of organic matter instead of chemical fertilizers to the soil will so completely eliminate insect pests and diseases that spraying will no longer be needed. The attractive printing and binding of this small book is enhanced by its woodcuts and end-papers. But how much better it would have been if the author could have presented some halftones to illustrate some of the conditions he has described and discussed.

ROBERT L. PENDLETON

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FARM SOILS. *Their Management and Fertilization. Fourth Edition.*

By Edmund L. Worthen. John Wiley & Sons, New York; Chapman & Hall, London. $3.80. xiv + 510 pp.; ill. 1948.

Although this edition maintains the textbook style of the third, considerable new material has been added. A careful comparison with the third edition, page by page, shows at least slight revision on more than half the pages. References to experiment station publications have been omitted. The treatment of soil erosion has been greatly expanded. Two new sections have been introduced, namely, on utilizing temporary pastures and on establishing poultry pastures. By implication, this book attempts to cover the soils of the entire United States. Actually, however, it is applicable mainly to the northeastern quarter of this country.

ROBERT L. PENDLETON

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SOIL FERTILITY. *English Version of the Revised Sixth Afrikaans Edition.*

By I. de V. Malherbe. Geoffrey Cumberlege, Oxford University Press, London, New York, and Cape Town. $6.50. xii + 296 pp. + plates; text ill. 1948.

This is an extremely interesting book, written in South Africa for use there. It has been written (a) for high school pupils who have chosen agricultural science as one of their subjects for the matriculation or senior certificate examination; (b) for prospective young farmers and soil-conservation officers who are attending the two-years' diploma and other courses at the Colleges of Agriculture; (c) as an introductory reader for university students who follow degree courses in Agriculture, Forestry, or Soil Conservation; and (d) for South African farmers of all ages who desire to increase their knowledge of the medium on which their prosperity depends. As the author says, these are the people who have 'to deliver the goods,' and they must accomplish this without leaving to posterity an impoverished soil. Again and again one notes statements that phosphorus is usually seriously deficient in South African soils—evidently this deficiency is widespread and serious.

This book is a refreshing change from the usual run of textbooks published on this same general subject in the United States. The translation into English has been done very well. If the price were not so high, it could be heartily recommended.

ROBERT L. PENDLETON

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A HANDBOOK OF TROPICAL AGRICULTURE.

By G. B. Masefield. Oxford University Press and Geoffrey Cumberlege, London. $4.00. viii + 196 pp. 1949.

Because of its comprehensive title this is a disappointing book. Moreover, the price seems exorbitant. After reading it, the reviewer, who has had a quarter century of agricultural experience in tropical Asia wrote to the author concerning the inadequacies and shortcomings of the book. The author replied that his book was partly intended to serve as a textbook for colonial service students who are taking short courses at universities in England and who, while not agriculturalists, have in a very short period to learn a little about tropical agriculture, with a strongly practical bias. He went on to say that his main job at the School of Agriculture of Oxford University is to teach such people. He also hoped that his book might be used in higher schools and colleges in Africa and other colonies. He added that students in England are nowadays very poor and in African colonies even more so. Hence the book had to be as cheap as possible, a factor which involved great condensation and such other restrictions as the absence of a bibliography. This also led him to draw his examples largely from the British colonies in Africa in greater proportion than from other areas. It is evident that even though this book may suffice for the purposes for which it was written, it cannot be recommended for North American readers nor for use in southeastern Asia.

ROBERT L. PENDLETON

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MINERAL DEFICIENCY IN PLANTS ON THE SOILS OF THE NINETY-MILE PLAIN IN SOUTH AUSTRALIA. *2. Effect of Zinc, Copper, and Phosphate on Subterranean Clover and*

Lucerne Grown on Laffer Sand, near Keith. Council for Scientific and Industrial Research, Bulletin Number 234.
By D. S. Riceman. Council for Scientific and Industrial Research, Melbourne. Free upon request (paper). 45 pp. + 16 plates. 1948.

This publication shows the extreme complexity of the problem of supplying the widely differing needs of different species of pasture plants growing together in the relatively very infertile Laffer sand. The beneficial effects of certain elements were not obtained without adding certain amounts of some other element or elements. But the interrelationships and amounts were found to differ for each of the important components of the pasture soil. Sixteen halftone plates help one to understand the magnitude of the effects found. The overseas reader will feel the lack both of an appropriate map of the region in relation to Australia as a whole, and of the botanical names of the several plants.

ROBERT L. PENDLETON

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FLOWERS IN WINTER.
By Patrick M. Synge. Lindsay Drummond, London. 15s. 122 pp. + 44 plates. 1948.

Written by an Englishman for English gardeners, this book can be read with pleasure and profit by gardeners anywhere. It concerns itself with the perennials, bulbs, tubers, and shrubs which, when judiciously used, can extend the flowering season into the winter months. To the American gardener, however, the title will be somewhat misleading, for many of the species discussed would be classified among our early spring rather than late winter flowers. Many, too, will not be hardy in our more northern states. The informed gardener will, however, recognize these discrepancies as due to the mildness of English winters while at the same time he will enjoy Synge's light, but discriminating, style and his excellent photographs. The colored plates are not on a par with the monochromes.

C. P. SWANSON

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THE GARDENER'S TRAVEL BOOK. *The Massachusetts Horticultural Society.*
By Edward I. Farrington. Oxford University Press, New York. $4.00. x + 278 pp. + 32 plates. 1949.

To the gardener who combines a love for travel with a love for gardening, this is a unique and invaluable volume. It is an index of the gardens of the United States, Canada, and Mexico, arranged alphabetically as to states and locations within states. But it is also much more than an index. In his descriptions of gardens, public and private, as well as commercial, Farrington has included a wealth of information on specialty plantings, availability to visitors, height of blooming season, etc., information which will permit the motoring gardener to plan an itinerary peculiarly suited to his desires with the least inconvenience in distance and time. Included are some sixty black-and-white photographs of excellent quality, depicting some of our most outstanding garden spots.

C. P. SWANSON

GENERAL AND SYSTEMATIC ZOOLOGY

PRÉCIS DE BIOLOGIE ANIMALE. *Third Edition, Revised and Corrected.*
By M. Aron and P. Grassé. Masson et Cie., Paris. 1100 fr. viii + 1235 pp.; ill. 1947.

The preface to this third edition states that because of the recent war, access by the authors to foreign publications in biology was difficult and at times impossible. Therefore this edition has not undergone any profound alterations, although certain paragraphs and even some chapters have been revised. The contents are divided into five parts: a) the cell and general phenomena of reproduction; b) cellular physiology; c) the life of organisms in a state of equilibrium; d) the animal groups; e) the evolution of organisms. Each of these is further subdivided into chapters. The coverage is broad, and the reviewer admits quickly and frankly that he hasn't read all the 1235 pages of the text. Examination of a chapter here and there has failed to reveal any major deficiencies that would have resulted from the writers' overlooking any of the more recent discoveries. Rather, the treatment is most up to date (e.g., *Australopithecus*, *Meganthropus*, and *Gigantopithecus* are included in the evolution of the Primates), especially when compared to many American text books. Indeed, it proves difficult to find a basis for comparing the present volume with certain standard American zoology text books. The amount of material included by Aron and Grassé is too great for any one year's work. It is more of a compendium of a full four years' major in zoology in this country (plus some graduate level work). Consequently it combines what we can find only in several textbooks for different courses, a sort of expanded combination of a "Plunkett" and a "Hegner." One wonders where such a book would fit into our zoological training system. There is no doubt that a candidate for an advanced degree, were he to read this one volume, would be prepared for any sort of examination. Naturally, each major topic fails in completeness of detail; and some fields, like ecology, are not even mentioned. On the other hand, it is convenient to have so much information all in one place, including, in spite of the broad field to be covered, bits of information not common in textbooks. There are 719 figures, most of which have been drawn from

European sources and for that reason are of additional value to American biologists. There is an index, but only a pretence of a bibliography.

Henri C. Seibert

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Traité de Zoologie: *Anatomie, Systématique, Biologie. Tome VI. Onychophores, Tardigrades, Arthropodes, Trilobitomorphes, Chélicérates.*
By M. André, L. Berland, L. Cuénot, C. Dawydoff, L. Fage, J. Millot, L. Störmer, M. Vachon, A. Vandel, and G. Waterlot. Masson et Cie., Paris. 5000 fr. viii + 979 pp. + 5 plates; text ill. 1949.

Traité de Zoologie: *Anatomie, Systématique, Biologie. Tome IX. Insectes: Paléontologie, Géonémie, Aptérygotes, Ephéméroptères, Odonatoptères, Blattoptéroïdes, Orthoptéroïdes, Dermaptéroïdes, Coléoptères.*
By L. Chopard, R. Denis, R. Despax, P.-P. Grassé, R. Jeannel, and R. Paulian. Masson et Cie, Paris. 4500 fr. viii + 1117 pp. + 3 plates; ill. 1949.

Traité de Zoologie: *Anatomie, Systématique, Biologie. Tome XI. Échinodermes, Stomocordés, Procordés.*
By P. Brien, M. Caullery, L. Cuénot, A. Dalcq, C. Dawydoff, P. Drach, H. Harant, and G. Waterlot. Masson et Cie., Paris. 3800 fr. viii + 1077 pp.; ill. 1948.

The appearance of a new treatise on zoology will be welcomed by zoologists the world over. The existing treatises are either so old as to retain very little value or else they remain, like the great German treatises, in a perpetually incomplete state, very exasperating to the user. The energy and speed with which the volumes of the French treatise are appearing—three in rapid succession in 1949 and others promised within a year or two—augurs well for the eventual completion of the set within a reasonable time, well before the first volumes have become outmoded.

In these volumes the emphasis is placed on anatomy and its handmaiden, embryology. Most of the space allotted to each group is given over to an account of the anatomy. This account is reasonably full and adequate, proceeding system by system, and well illustrated by large, clear, and neat figures, in many of which color has been employed to emphasize certain systems. This is followed by an account of the embryology, then by a brief section on systematics, which wisely makes no attempt to go beyond genera, and by a closing discussion of phylogenetic questions. The outstanding defect of these excellent volumes is the almost complete lack of any discussion of ecological and physiological topics. This appears to the reviewer a most unfortunate omission that lends an impression of old-fashionedness to what is otherwise a highly satisfactory performance. The bibliographies at the end of each group are limited to the larger works, and there is little documentation in the text.

The treatise is announced to consist of 17 volumes, of which there have appeared in 1949 volumes XI, VI, and IX, dealing with invertebrates and prochordates.

Volume XI. Échinodermes, Stomocordés, Procordés. The account of the echinoderms, by L. Cuénot, is happily given over mainly to the living groups, classified into the usual five classes, and thus avoids that undue emphasis on fossil echinoderms that was the glaring defect of the echinoderm volume in Lankester's *Treatise on Zoology.* The fossil echinoderms are briefly treated as classes Machaeridia, Heterostelea, Cystidea, Blastoidea, and Edrioasteridea. The last is considered phylogenetically important for the origin of the living groups. A generous section on echinoderm embryology and metamorphosis, by C. Dawydoff, suffers from the habitual tendency of this author to produce his own or at least unfamiliar names for many embryonic features. The dipleurula larva is accepted as the point of departure for discussions of phylogenetic questions regarding echinoderms. It is considered to indicate an original bilaterality that was altered by the assumption of a fixed mode of life. The dipleurula larva is presumed to have attached by its preoral lobe, and possibly an asymmetrical mode of attachment may account for the suppression of the right side in favor of the left so characteristic of echinoderms. It is accepted that all free-moving groups of present echinoderms descended from fixed ancestors.

The Hemichordata, also by Dawydoff, are treated under the name Stomochorda, to avoid implications of the former name. There is an excellent account of the group, divided into the usual two classes, Enteropneusta and Pterobranchiata. The two peculiar organisms *Planctosphaera*, found in 1910 by the Michael Sars Expedition and later also elsewhere, and Siboglinum, collected in the Malay Archipelago by the Siboga, are presented as undoubtedly of hemichordate affinities. There is also included in the phylum the fossil group of graptolites, as a class Graptolitoidea. The graptolites were formerly thought to be coelenterates but researches of recent years leave little doubt of their affinity with the Pterobranchiata. The notion of the notochord affinity of the anterior diverticulum of the typical hemichordates is altogether rejected, and the structure, termed "stomochord," is considered to represent an anterior part of the pharynx that once opened by a mouth anterior to the present mouth. Chordate affinity of the hemichordates is, however, accepted, mainly on the ground of the presence of gill slits (pharyngotremy) which are presumed to have originally extended the length of the digestive tract. Echinoderm affinity is also affirmed on the basis of larval similarity.

The tunicates are given an extensive treatment by P. Brien, aided by A. Dalcq and P. Drach in some general introductory remarks. The last author rightly rejects the conception of a group Prochordata to embrace tunicates and cephalochordates and retains these as separate subphyla of the Chordata. The volume closes with an account of the Cephalochordata by P. Drach, who considers this group to represent a small side branch of the chordate stem, without direct ancestral relationship to the vertebrates.

Volume VI. Onychophores, Tardigrades, Arthropodes, Trilobitomorphes, Chélicérates.

The onychophores, tardigrades, and pentastomids, handled by L. Cuénot, are excluded from the phylum Arthropoda although regarded as closely allied to it. The Arthropoda are divided into the subphyla Trilobitomorpha, Chelicerata, and Mandibulata or Antennata. An interesting introductory chapter to the Arthropoda, by A. Vandel, precedes the more specific accounts. Vandel concludes that it is impossible to homologize the different body regions and segments of groups of arthropods and that the conception of a primitive arthropod body of 21 segments is unacceptable and false. An annelid affinity of arthropods is accepted.

The Trilobitomorpha, divided into the classes Trilobita, Merostomoidea, Marellomorpha, and Pseudocrustacea, are discussed by L. Störmer, who submits that these somewhat diverse groups are united by their common possession of a trilobite type of appendage. They are probably related to the Chelicerata.

The remainder of the volume is devoted to the Chelicerata, divided into the classes Merostomata, treated by L. Fage; Arachnida, handled by L. Fage, J. Millot, C. Dawydoff, M. Vachon, L. Berland, M. André, and G. Waterlot; and Pycnogonida, by L. Fage.

Volume IX. Insectes. Paléontologie, Géonémie, Aptérygotes, Ephéméroptères, Odonatoptères, Blattoptéroides, Orthoptéroides, Dermaptéroides, Coléoptères.

This volume begins with some general chapters on insects, including fossil insects, by R. Jeannel. This author accepts the classification of Martinov, who has divided the insects into the subclass Apterygota, with four orders, and the Pterygota, with 33 orders. Distinction is also made between the Paleoptera, with seven orders, in which the wings cannot be folded, and the Polyneoptera, with 26 orders, in which the wings are folded together in repose. The section on fossil insects attempts to correlate the evolution of insects with successive topographies of the various geologic ages.

The remainder of the volume deals with the lower orders of insects and is written by a number of authors (L. Chopard, R. Jeannel, R. Denis, P. Grassé, R. Despax, and R. Paulian). Like the rest of the treatise, these articles are mainly anatomical, with only brief considerations of habitat relations and geographical distribution. Exception may be made of the chapter on termites, by P. Grassé, in which there is a considerable discussion of the determination of castes, the social life of termites, the morphological and ecological peculiarities of the various castes, the symbiotic relationship with flagellates, and the various types of nests and mounds.

L. H. HYMAN

* * *

A MONOGRAPH OF THE ECHINOIDEA. *IV.1. Holectypoida, Cassiduloida. IV.2. Text and Atlas. Clypeastroida: Clypeastridae, Arachnoididae, Fibulariidae, Laganidae and Scutellidae. (2 Vols.)*

By Th. Mortensen. C. A. Reitzel, Copenhagen. (IV.1) D. Kr. 62.00; (IV.2) D. Kr. 100.00 (paper). (IV.1) viii + 372 pp. + 14 plates; text ill. (IV.2, Text) viii + 471 pp.; ill. (IV.2, Atlas) viii + 20 pp. + 72 plates. 1948.

These three paper-covered volumes represent the fourth part of Mortensen's well-known monograph on the Echinoidea and, like the preceding parts, will prove indispensable to all students of this group.

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A GENERAL TEXTBOOK OF ENTOMOLOGY *Including the Anatomy, Physiology, Development and Classification of Insects. Seventh Edition.*

By A. D. Imms. E. P. Dutton & Co., New York. $12.50. xii + 727 pp.; ill. 1948.

The changes by which this edition differs from earlier ones are of minor significance. The most up to date of the supplementary references is that to Comstock's general textbook, 1940. This new edition is thus at least ten years old. Not least of the dangers inherent in the manifest reedition of old, tried-and-true textbooks lies in the fact that erroneous information is perpetuated. Witness, for example, the discussion of campaniform sense organs (p. 96). This concludes with the statement that "... their true sensory function remains problematical." Yet more than ten years ago Pringle, in England, demonstrated conclusively that campaniform sensilla are proprioceptors (*J. exp. Biol.*, 15: 114–131. 1938).

The excellence of Imms' great work has not diminished through the years, but anyone who already possesses an earlier edition will have little to gain by acquiring the seventh.

V. G. DETHIER

* * *

HOW TO KNOW THE IMMATURE INSECTS. *An Illustrated Key for Identifying the Orders and Families of Many of the Immature Insects With Suggestions for Collecting, Rearing and Studying Them.*

By H. F. Chu. Wm. C. Brown Company, Dubuque. $3.00 (cloth); $2.00 (spiral). vi + 234 pp.; ill. 1949.

This interesting volume is one of The Pictured-key Nature Series edited by H. E. Jaques. The subtitle clearly describes its contents. Almost the entire volume consists of keys, with the illustrations so arranged as to explain the characters used. It is not possible for a reviewer to do more than call attention to the well arranged order of the work, its clear illustrations, and its brevity. Anyone using the keys will find many difficulties and errors that will try his patience; yet the attempt to do the almost impossible in devising satisfactory keys to the immature stages of the various orders and numerous families of insects is to be highly commended. The author gives the beginner a brief but interesting account of the early stages of insects and how they may be collected, reared, and preserved. There is an adequate index and a pictured glossary arranged in a single unit. The bibliography is not very complete.

Robert Matheson

* * *

Les Cochenilles de France, d'Europe, du Nord de l'Afrique et du Bassin Méditerranéen. *Monographie des Coccoïdea Classification—Diaspidinae (Première partie). Actualités Scientifiques et Industrielles, 1054; Entomologie Appliquée, IV.*

By A. Balachowksy; illustrations by Gérard Langlois. Herman & Cie., Paris. 600 fr. (paper). 154 pp. [Pp. 241–394 of set]; ill. 1948.

Of the six volumes planned for the *beginning* of this ambitious work on palearctic coccids, Balachowksy has now published the first four, the present volume having been long delayed by the war. Volumes I and II appeared in 1937, and III in 1939. The first three volumes complete a general study of the scale insects, especially of their morphology, while this fourth volume considers the major taxonomic groupings inclusive of the subfamilies, and embarks on the revision of the first group (Diaspidinae: Aspidiotini: Aspidiotina), of which 32 species in 9 genera are considered in detail.

The present volume is printed on heavy pulp, is uncut, and has a paper cover, but the reproduction of the 32 full-page line cuts is adequate. The manuscript could have been edited more closely, for there are a few inconsistencies in format and errors in pagination and spelling of proper names that should have been corrected. But one's general impression is very favorable, with the reservation that the value of the work will depend greatly on the publication of the rest of it. The key to genera, as well as the full bibliography, are due at the end of each group revised, so that one must wait for volume VI in order to find those for the tribe Aspidiotini.

The author divides the Homoptera into superfamilies, with the Coccoïdea for the scale insects. The Cicadoïdea (inclusive of the Cicadidae, Cercopidae, Membracidae, etc.) Amphidoidea, Aleyrodoidea, and Psylloidea represent the other divisions. Under the Coccoïdea he recognizes three families with 14 subfamilies (in contrast to 1 family, 17 subfamilies by MacGillivray, 1921; and 11 families by Ferris, 1937). One can well object to the author's spelling of the family names (Margaroïdae, Lecanoïdae, and Diaspidoïdae) as unorthodox and confusing, but since the significant categories, namely, the subfamilies, are in standard form, it matters little. Full keys from superfamilies to subfamilies are given, with further keys to the tribes of the Diaspidinae and the subtribes of the Aspidiotini to cover the present volume and the succeeding two volumes.

The bulk of volume IV is a monograph of the genera and species of the subtribe Aspidiotina, of which one genus is new (*Abgrallaspis*, proposed for 6 species of palearctic *Hemiberlesia*, genotype *H. cyanophylli* Signoret). Each genus is fully characterized, with the genotype given (but status of designation not clear for most) for all but *Chortinaspis* Ferris, which is an unexplained omission. The treatment of each species is rather complete, with a conventional split figure (full page line-cut) for the pygidium, with border detail as an enlargement. The author considers for each species its synonymy, reference to principal descriptions and to biological observations, diagnostic characters both macroscopic and microscopic, biology and habitat, distribution, natural enemies, and relations to other species.

An interesting problem of format is posed by the use of double pagination in these volumes, i.e., pagination for the *set* as well as for the volume. Generally speaking, such a system is hard for the author and reader to keep in order, as evidenced by the text citations, which are in pagination for the set, while the volume index is in pagination for the volume. Occasional confusion by the author himself (in the key to *Chortinaspis*, IV-143, and the text references, IV-66) illustrates the point.

Robert Matheson

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Atlas des Lépidoptères de France. *Belgique, Suisse. III. Hétérocères (fin).*

By Claude Herbulot; illustrations by R. Préchac. Éditions N. Boubée et Cie., Paris. 480 fr. (paper). 146 pp. + 12 plates; text ill. 1949.

This new volume to the series maintains the same high standards and excellent illustrations evident in the other volumes.

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New Guinean Reptiles and Amphibians in the Museum of Comparative Zoölogy and United States National Museum. *Bulletin of the Museum* *of Comparative Zoölogy at Harvard College. Volume 101, Number 2.*

By Arthur Loveridge. Museum of Comparative Zoölogy, Cambridge. $1.50 (paper). Pp. 303–430. 1948.

During the war many amateur and professional zoologists found themselves in what they would previously have considered to be remote corners of the earth. Many of them, due to the limiting effects of time, climate, materials, enemy action, or inclination, obtained only a handful of herpetological specimens that reached museum collections. A few were able to amass outstanding collections. Such was the material assembled by William H. Stickel, a collection which is described by Loveridge as the best he has seen from New Guinea. It is difficult to realize how important these contributions are. For example, the present paper is based upon 1809 specimens in two museums. Of these, over one-third were collected by Stickel and another third by two other interested zoologists, William H. Beck and P. J. Darlington. The remainder of the specimens were derived from an expedition, from exchanges with museums from all over the world, and from dozens of individual donations. How much more is yet to be done in New Guinea in this field of work is emphasized by Loveridge's statement that this material represents only 44 per cent of the forms known to occur there.

The New Guinean amphibian and reptilian fauna that Loveridge lists consists of 108 forms of frogs, 17 turtles, 2 crocodilians, 146 lizards, and 95 snakes. Besides listing the known herpetofauna, he has discussed the forms represented in the material studied, species by species, with a varying amount of detail per species. There are occasional keys, but no general attempt was made along those lines, inasmuch as "to compile keys on so slender a representation would inevitably lead to the perpetuation of many errors, for some of the names included in the list will certainly prove to be synonyms." Other useful features of the paper include a Gazetteer of all New Guinean localities mentioned in the text, and a list of the literature cited. Loveridge is a careful and meticulous worker with a tremendous knowledge of the herpetology of the eastern hemisphere. It is doubtful if there are many others who could have done so excellently with the same material and in the same period of time.

This appears to be an appropriate place to discuss a general problem faced by authors of faunistic studies. Suppose such an investigator wants to devote a limited, albeit substantial, amount of time to a faunal report. He finds two possible methods of using material if the time factor is to be kept within reasonable bounds. Either he can study the forms from a small geographic area but with a serious attempt to examine all the specimens in various museums collected from the area in question. Or he could study the fauna of a much larger area but with limitation to the use of the collections of a single institution. The amount of work, as measured by the number of specimens carefully studied, might be approximately the same in the two cases. In the first, however, the forms of a restricted area would be relatively well-known, whereas in the second perhaps as much biological information would be made available, but it would be spread thinner over a much larger area.

In the past, Loveridge has been in the company of a small number of curators who have rather consistently followed the second procedure. No doubt he has viewed it as his primary responsibility to describe adequately the material entrusted to his care in the Museum of Comparative Zoology. Other curators, however, view (or are permitted or encouraged to view) their responsibilities somewhat differently and normally follow the alternate procedure. In the present paper, Loveridge has made use of an additional collection besides his own, namely, that of the United States National Museum. Whether this indicates a change in policy in herpetology at the Cambridge institution or only an expedient measure because of an unusual set of circumstances, only time will tell. Loveridge hints that the latter is true and that, therefore, no persistent change is to be expected. Many, however, will hope with the reviewer that this paper indicates a real trend towards a change in procedure. If there are to be, for example, three studies on three island faunas, a literature with three such titles as "The Frogs of Islands A, B, and C in the X Museum," "The Frogs of Islands A, B, and C in the Y Museum," and "The Frogs of Islands A, B, and C, in the Z Museum" would not be as desirable as a literature with the three titles "The Frogs of Island A" by the Curator of X Museum, "The Frogs of Island B" by the Curator of Y Museum, and "The Frogs of Island C" by the Curator of Z Museum. The more intensive work on the individual islands should, in general, precede the comparative studies of the faunas of these islands. In all fairness, however, it should be pointed out that there are frequently extenuating reasons for reporting on a single collection from an area in a separate publication.

ARNOLD B. GROBMAN

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REPTILES FROM THE INDIAN PENINSULA IN THE MUSEUM OF COMPARATIVE ZOÖLOGY. *Bulletin of the Museum of Comparative Zoölogy at Harvard College, Volume 103, Number 2.*

By John D. Constable. Museum of Comparative Zoölogy at Harvard College, Cambridge. $1.25 (paper). Pp. 57–152. 1949.

Several years ago I had a conversation with an informed and well-rounded biologist whose field of special interest is plant physiology. We were discussing the characteristics of good taxonomic work. He pointed out that, were he in a position to add a new member to his staff, he would welcome a taxonomist who was concerned with the relationships among the organisms he was dealing with; he would not, however, be interested in a man who considered the pure cataloging of material to be his terminal job. It seems obvious that my physiologist friend would never offer a position to the author of this paper. For we find Constable saying on the initial page of his report:

"Taxonomy in itself may seem to be of rather little use, but it is an essential adjunct to other important areas of biology. I believe it to be, in general, a tool developed by scientists for their convenience and that therefore the rules and methods that are adopted for its development should be largely determined by their usefulness rather than by more or less abstract concepts of 'natural distinctions.' It may, for example, be true that two races of snakes can be distinguished on the basis of differences in the hemipenis, but I consider the difference to be unworthy of taxonomic recognition as long as the females are indistinguishable. Even if the hemipenis differences should be shown to have such a profound effect upon their breeding habits as to prevent crossbreeding of the two forms, I would still consider a new name inconvenient and hence, almost by definition, unnecessary."

In recent years we have been favored with many treatments about taxonomic procedure: *The New Systematics; Systematics and the Origin of Species; Evolution, the Modern Synthesis;* and *Genetics, Paleontology and Evolution.* For a serious student of taxonomy to hold to a pre-Darwinian and pre-Mandelian concept about systematic procedure in the face of such literature is, indeed, a most amazing anachronism. Such a performance lends support to the thesis that there are two kinds of persons studying the classification of animals: taxonomists and systematists.

There are two steps in good systematic work. So far I have decried the lack of the author's appreciation for the second step. The first step is the association of animal characters with animal names. This seems to have been done carefully and well in the present study. Constable found 775 Indian specimens in the Museum of Comparative Zoology representing two forms of crocodilians, 13 turtles, 93 lizards, and 112 snakes. Two new species are described, one a gecko and the other a small burrowing blind snake of the genus *Typhlops.* Under each species there is given the original citation, the type locality when definable, and the catalogue numbers of the specimens in the M. C. Z. There are also given locality data and taxonomic characters for the specimens at hand. The latter are quite extensive in some cases and, in a few instances, keys have been prepared to distinguish closely allied forms.

The paper closes with a list of the literature cited which is erroneously headed: "Bibliography." The review copy was incomplete in that the last signature was missing.

ARNOLD B. GROBMAN

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SNAKES.

By Herbert S. Zim; illustrated by James Gordon Irving. William Morrow & Company, New York. $2.00. 66 pp.; ill. 1949.

The young naturalist should be fascinated by this book on snakes. Dealing with the biology of snakes in a comprehensive manner, it will do much to place the snake properly in the biological order of things, as well as to remove the fears and superstitions which surround them. The kinds of snakes, their modes of reproduction and feeding, and their care are handled in straightforward simple sentences, and balanced with a fine group of black-and-white drawings by J. G. Irving. It is recommended for the growing and inquisitive naturalist.

C. P. SWANSON

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BOY'S BOOK OF SNAKES. *How to Recognize and Understand Them.*

By Percy A. Morris. The Ronald Press Company, New York. $3.00. viii + 185 pp.; ill. 1948.

Good books about snakes for the beginner are few. In fact, those designed to be read for entertainment rather than used like a manual can be counted on the fingers of one hand. The *Boy's Book of Snakes* is a highly simplified and well-written account, with emphasis on the species common in the United States (seven chapters) but including a very brief account of foreign forms (two chapters). The treatment is largely ecological and omits scientific names. However, all kinds mentioned are classified in a list that precedes the index. There is also a list of authorities cited and a brief bibliography. Some of the numerous half-tone illustrations are good, others poor.

A few errors have crept in. Stejneger's myth of the rattler 8 feet 9 inches long has been perpetuated, along with the belief that poisonous snakes usually make only two punctures when they bite. Nevertheless, I would not hesitate to recommend this little book to a boy or girl with a growing interest in reptiles.

CLIFFORD H. POPE

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BIRDS. *A Guide to the Most Familiar American Birds. A Golden Nature Guide.*

By Herbert S. Zim and Ira N. Gabrielson; illustrated by James Gordon Irving. Simon and Schuster, New York. $1.00. 157 pp.; ill. 1949.

While not as comprehensive in treatment as the field guides by Peterson, this pocket volume is an excellent book for the beginner. The colored illustrations by J. G. Irving are accurate in color and proportion; and the descriptions, while brief, provide the necessary supplementary data on distribution, habitats, and habits. A table at the back of the book provides a compact summary of migration dates, egg size and number, nesting materials and location, and food habits.

C. P. SWANSON

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CATALOGUE OF BIRDS OF THE AMERICAS AND THE ADJACENT ISLANDS IN FIELD MUSEUM OF NATURAL HISTORY. *Including All Species and Subspecies Known to Occur in North America, Mexico, Central America, South America, the West Indies, and Islands of the Caribbean Sea, the Galapagos Archipelago and Other Islands Which May Be Included on Account of Their Faunal Affinities. Jacanidae, Rostratulidae, Haematopodidae, Charadriidae, Scolopacidae, Recurvirostridae, Phalaropodidae, Burhinidae, Thinocoridae, Chionididae, Stercorariidae, Laridae, Rynchopidae and Alcidae. Zoological Series, Field Museum of Natural History, Volume XIII, Part I, Number 3, Publication 616.*

By Charles E. Hellmayr and Boardman Conover. Field Museum of Natural History, Chicago. $4.00 (paper). vi + 383 pp. 1948.

The present number of this extensive catalog of birds of the Americas (Western Hemisphere) lists the members of the Order Charadriiformes. This order includes the jacanas, painted snipe, oyster-catchers, plovers, sandpipers, curlews, avocets, stilts, phalaropes, thick-knees, seed-snipe, sheath-bills, skuas, jaegers, gulls, terns, skimmers, and auks, a group commonly known as the shore-birds, although it obviously contains members not limited to coast lines.

The greater part of the manuscript was written by Hellmayr, and since his death has been supervised, emended, and brought up to date by the junior author. As in previous numbers of the series, each species and subspecies of bird known to occur in the Western Hemisphere has been listed with complete synonymy and bibliographic references up to 1945. New forms that have been described and a few important papers that have appeared since that date are mentioned in footnotes. Specimens in the Field Museum and in the Conover collections are listed according to locality. The range of each form is delimited. For anyone interested in avian taxonomy, this publication, like its predecessors, is a necessary and invaluable reference. For others, the extensive references will provide a good start for anyone who seeks information about a particular species, especially since the important data in each reference cited have been indicated following the citation.

HENRI C. SEIBERT

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ANIMAL ENCYCLOPAEDIA. *Mammals. With Latin Index.*

By Leo Wender. Oxford University Press, New York. $4.50. 266 pp.; ill. 1949.

In the Foreword it is confidently stated that "this dictionary of animals seeks to give everybody—laymen and scientists—a short and concentrated account of the most interesting facts concerning the mammals of the world." Some 1500 mammals are listed alphabetically by their "common" English names, ranging from aardvark, acouchy and addax to zeren, zorille, and zwart-wit-pens. What this work considers as "the most interesting facts" concerning these beasts is best indicated by the first sample the reviewer happened to read: "ALPINE PIPISTRELLE, a southern Pipistrelle going above the treeline in the Alps. Usually sleeps in the cow-chalets. Body 2 in., tail 1⅓ in. long; wing-span 9 in. *Pipistrellus savii.*" From this the lay-reader can learn little besides that the particular winged critter sleeps in a cow-chalet (a novel architectural term). The numerous, far too small, and extremely poorly reproduced illustrations are of no help in identifying the animals, which can not be recognized from the text either. Many of the technical names of species and of the arbitrarily selected subspecies are not up to date.

Appended is a list of Gestation Periods and Numbers of Young at a Birth, which irritates the expert by making claims unsupported by any references to the literature. Thus, it lists the duration of pregnancy for the marmoset as "75—150 days," which is surely liberal enough to include the correct figure; whereas for the macaque 7 months is given, although 5½ months is all that has been well substantiated so far. Another appendix contains a Classification of Mammals which is inexcusably crude. Man is not even mentioned. The "Lemuroids" form a separate order, containing the families "Lemurs, Slow Lemurs and Tarsier," although in the text the Lemuroids are defined as representing a "sub-order of the Primates" and as "the chief elements of the mammalian fauna of Madagascar."

Enough has been said to indicate that this is a pot-boiler of the worst sort, written by someone of whom it is merely stated that he "was contributing author of the *Guide to the Berlin Zoo* and has spent over ten years in the preparation of this Encyclopaedia." It is hoped that this volume will reach all cross-word-puzzle fans, but no one who is seeking reliable zoological information on matters beyond the spelling of the names of mammals.

A. H. SCHULTZ

MAMMALS OF NORTHERN COLUMBIA. *Preliminary Report Number 4: Monkeys (Primates), With Taxonomic Revisions of Some Forms. Proceedings of the United States National Museum, Volume 98, Number 3232.*

By Philip Hershkovitz. Smithsonian Institution, United States National Museum, Washington, D. C. Paper. Pp. 323–427 + 3 plates; text ill. 1949.

The author of this scholarly study has collected over 200 specimens of capuchin monkeys, spider monkeys, howler monkeys, night monkeys, and marmosets in northern Colombia. Based upon this extensive new material, as well as upon an examination of nearly all pertinent type specimens and additional material from many other collections, a much needed taxonomic revision has been made, chiefly of the genera *Cebus* and *Marikina*. All these Colombian primates are described according to geographical distribution and the corresponding detailed differences in the characters of their hair, skull, and dentition, as well as, in the genus *Alouatta*, its highly specialized hyoid apparatus. The many technical and well documented results have not been summarized in the report and cannot be briefly summarized here. It suffices to mention that this paper will be indispensable for students of the taxonomy and geographical distribution of New World monkeys.

A. H. SCHULTZ

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ECONOMIC ZOOLOGY

GALL MIDGES OF ECONOMIC IMPORTANCE. VOLUME IV: GALL MIDGES OF ORNAMENTAL PLANTS AND SHRUBS. *Agricultural and Horticultural Series.*

By H. F. Barnes; with a Foreword by G. Fox Wilson. Crosby Lockwood & Son, London. 15s. 165 pp. + 10 plates; text ill. 1948.

The title clearly indicates the scope of this volume. In the beginning there is a list of all the plants (43) treated, each with its known gall midges and the part injured. These are all discussed in detail in the following pages. The arrangement is most satisfactory, for the reader can select any plant, glance down the pages and find the list of known midges with the page references where he can find detailed accounts of the various species. Furthermore, under the discussion of each gall the author has obligingly given the most important references dealing with the species that causes the gall. Could anyone ask more? The book is most delightfully written, and the reader will learn much of interest.

Under each gall discussed there is a full account of the parasites and predators. Where control measures have been devised, these are given, and the author appears to be well acquainted with much of the work done in all parts of the world, especially in America.

This book should be a welcome addition to the library of everyone interested in knowing these galls and in keeping their ornamental plants and other shrubs free from these pests. To the entomologist the illustrations will furnish a guide to many of the midges that form these galls, inasmuch as they can be identified by their work whereas identification of the midges themselves is very difficult.

Decided attractions are a bibliography of 343 titles, a list of generic, specific, and common names of all the midges described in the book. Two indexes, one for plants and one general, complete the volume.

ROBERT MATHESON

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THE STOCK OF SALMON: *Its Migrations, Preservation and Improvement, being The Buckland Lectures for 1947.*

By W. J. M. Menzies. Edward Arnold & Company, London. 5s. 96 pp. + 7 maps; text ill. 1949.

"That fact that wide variations in the catch of salmon, and therefore presumably in the stock of salmon, exist from year to year is very much better known than the causes of these variations." The author finds no convincing evidence for population cycles in Atlantic salmon, and although weather conditions may sometimes influence the population over wide areas, the greatest influence on the stock seems to be in the sea. Grilse present an interesting puzzle, for although a large grilse run may indicate a large adult run the next year, the reverse is not necessarily true. The author asks how a stock might be adversely influenced in its early years without impairing its final yield. Many migration patterns from various tagging stations are presented in the figures, but here again the data are inconclusive. This concise summary (the latest of the Buckland Lectures) of our present state of ignorance of an intensively studied fish should be salutary reading for the more dogmatic fisheries biologists—we have hardly begun to learn what goes on in the sea.

J. W. HEDGPETH

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FISHERY STATISTICS OF THE UNITED STATES 1945. *United States Department of the Interior, Fish and Wildlife Service. Statistical Digest 18.*

By A. W. Anderson and E. A. Power. United States Government Printing Office, Washington, D. C. $1.50 (paper). ii + 372 pp.; ill. 1949.

THE HATCHABILITY OF CHICKEN EGGS AS INFLUENCED BY ENVIRONMENT AND HEREDITY. *A Revision of Bulletins 216 and 236. Bulletin 262.*

By Walter Landauer. Storrs Agricultural Experiment Station, Storrs, Connecticut. 50 cents (paper). 231 pp.; ill. 1948.

This bulletin is a comprehensive summary of research on inherent and environmental factors which affect the probability that viable chicks will hatch from hen's eggs following incubation. Sixteen lethal genes and several other genes that reduce embryonic viability are described. Requirements of the developing embryo with respect to temperature, humidity, gaseous environment, orientation, and turning are reviewed. The nutrition of the hen, determining the amount of the respective vitamins, except C, in the hen's egg, and research demonstrating the requirements of the developing embryo for the various vitamins are summarized. The influence of the age of eggs when incubated, the reproductive activity of the parental stock, the growth and physiology of the embryo, and the history of incubation all receive attention. Every research worker who uses chicken eggs, and every teacher of embryology should read this bulletin.

T. C. Byerly

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Fertility and Hatchability of Chicken and Turkey Eggs.

Edited by Lewis W. Taylor. John Wiley & Sons, New York; Chapman & Hall, London. $5.00. xii + 423 pp.; ill. 1949.

This book is an excellent summary of research on reproduction in chickens and turkeys. It should become a standard reference for every laboratory using eggs, embryos, chicks, or poults. Thoughtful poultry breeders, hatcherymen, and service and technical personnel in the feed, biological, and equipment industries will find it constantly useful. The book lacks a section on the normal morphological development of the embryo. Treatment of research on the growth of the embryo is inadequate. The chapter on Physical Conditions in Incubation, by Insko, is of outstanding value.

T. C. Byerly

* * *

PARASITOLOGY

Le Parasitisme. *"Que Sais-Je?" Le Point des Connaissances Actuelles.*

By Louis Gallien. Presses Universitaires de France, Paris. 45 fr. (paper). 128 pp.; ill. 1943.

This volume is number 117 of a proposed 160 titles in a series known collectively as "Que sais-je?" The topics run a gamut from a history of the theater, French diplomacy, the life of the blind, to scientific titles dealing with television, the nervous system, the migration of animals, or the present one on parasitism. They are, of course, intended for popular consumption. The story of parasites is interestingly recounted and made sufficiently lucid for the educated layman, but is not pitched at such a low level that essential details are glossed over. There are eight chapters, the first of which defines the subject by illustrating the various degrees of associations that may exist between two forms of animals, from commensalism to parasitism. This point is well brought out by using as an illustration the relations of closely related species of paguran crabs with their respective commensals, symbionts, and parasites. Chapter II points out the wide distribution of parasites within the animal kingdom (plant parasites are not considered). The next two chapters are concerned with certain parasitic adaptations; their regressive development with respect to related free-living forms, and specializations in holdfast structures. Chapters V and VI discuss reproduction, the cycles, hosts, fecundity, and associated phenomena. Number VII describes the effects of parasite on host; and the final chapter is a discourse on evolution, wherein it is pointed out that parasites at once provide evidence for the evolutionary doctrine and at the same time pose problems on the origin of adaptive features. Although brief and at times fragmentary, the book still provides enlightening information to anyone who has an hour or so on his hands and who is willing to spend it by reading in order to increase his "Je sais que."

Henri C. Seibert

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Veterinary Clinical Parasitology.

By Edward A. Benbrook and Margaret W. Sloss. The Iowa State College Press, Ames, Iowa. $4.50. viii + 187 pp.; text ill. 1948.

The most valuable feature of this book is the collection of many good photomicrographs of parasites of veterinary importance. Since the book is strictly limited to the clinical aspects of the subject, only the diagnostic stages of the parasites are illustrated. Usually each intestinal organism is presented in photographs taken at two magnifications, 100x and 410x. This makes it possible to compare the relative sizes of the organisms under the low power and high dry objectives of the compound microscope. The photographs of the ectoparasites were taken at lower magnifications. In all, there are approximately 240 photographs each of which occupies one half of a page. Twenty-three of the photographs illustrate techniques; 18, lice; 44, mites; 18, pseudoparasites; and the remainder, various intestinal parasites. Most of the photographs are very clear and have reproduced well.

Except for describing techniques, there is very little text in the first half of the book, which deals with intestinal parasites. For this reason, it would appear that the title is too broad for the material presented. The term "atlas" or "illustrated guide" would have been appropriate to qualify the title. Even as a guide, it would have been more complete and useful had the authors included descriptions of the diagnostic stages, host parasite lists, and perhaps notes on pathogenicity.

The text on the ectoparasites is more complete. In most instances, there is a general description of each genus, including its morphological characteristics and the effect of the parasite upon the host. The description of the genus is followed by a list of species with the names of the host that they parasitize. There is also a table to the characteristics of the mange and scab mites, accompanied by ten clear outline drawings to illustrate the male and female characters described.

The book has been planned so that other chapters can be added as needed and as the illustrative material becomes available. It now deals with only three groups: the intestinal parasites, the lice, and the mites. At the end of the book there are reference lists to each chapter and a detailed index.

M. M. Brooke

Veterinary Helminthology.

By Banner Bill Morgan and Philip A. Hawkins; illustrated by Everett L. Schiller. Burgess Publishing Company, Minneapolis. $7.00. xiv + 400 pp.; ill. 1949.

This is a very practical book that should prove to be a valuable possession to veterinarians and others interested in helminths of domestic and wild animals. It is apparently the first book of such proportions to present a well-rounded treatise of the subject of veterinary helminthology. It should not only serve as a well balanced textbook, but in view of its clear organization it will undoubtedly be a ready reference book for those who occasionally have need of specific information on various helminths.

The opening chapter is devoted to an introduction to the subject (history, types of parasites, immunity, etc.) and general discussions of the phyla and major classes of helminths. The generalized life cycles are presented along with the morphology of the various stages. Following the introduction there are seven chapters on the helminths of different hosts—horse, cattle, sheep and goat, swine, dog and cat, poultry, and fur bearers. The parasites of a given host are presented in a taxonomic order according to the classification of the three phyla (Platyhelminthes, Nemathelminthes, and Acanthocephala) as given in the introductory chapter.

Although the length of the discussions depends upon the importance of the parasite and the information available, the pattern of presentation is essentially the same for each. The more lengthy discussions generally hold to the following outline: synonyms, common name, disease, hosts, morphology, location, life cycle, symptoms, pathology, diagnosis, treatment, prevention and control, and general remarks. The general remarks usually include information on prevalence, distribution, and veterinary importance. It is evident on practically every page that there is a great deal not yet known about veterinary helminthology. The authors hope that the direction of attention to these gaps in our knowledge will stimulate investigators to find the needed information.

The last chapter outlines the various techniques for recovering and identifying helminths in fecal specimens, tissues, or blood. There is also a discussion of postmortem examinations of animals for parasites and evidence of their effect upon the host.

The book is profusely illustrated by clear outline drawings organized into 58 full-page plates. Although some of the plates give the generalized morphology and life cycles of the worms, most of them stress the diagnostic characteristics of eggs, larvae, and adults that are found in clinical material. Unfortunately, references to the figures are not made in the text. It is therefore frequently necessary to consult the index to determine if an illustration of the organism has been included. Five spot maps give the known locations of some of the parasites with a restricted geographical distribution in this country. All of the maps and most of the drawings are original. The appendix is reserved for a host-parasite list, and for references to books and publications dealing with veterinary helminthology. At the end of each chapter there is also a list of selected references.

M. M. Brooke

ANIMAL GROWTH AND DEVELOPMENT

Structure and Development of the Vertebrates: *A Manual for an Integrated Course in Comparative Anatomy and Embryology. Prentice-Hall Animal Science Series.*

By Florence Moog. Prentice-Hall, New York. $3.50. xiv + 170 pp.; ill. 1949.

This book is primarily a laboratory manual designed to serve the needs of a course in which the usual subjects of comparative vertebrate anatomy and comparative vertebrate embryology are integrated into a single sequence. The book contains some textual material, but it is intended to be used in conjunction with standard textbooks of comparative anatomy and embryology. The manual was developed in connection with a course which the author has taught at Washington University for three years.

The first chapter introduces typical features of vertebrate form, as exemplified by Ammocoetes. The next two chapters are devoted to the early embryology of the frog and chick, respectively. Development through gastrulation and the assumption of body form is considered in these chapters, with emphasis on the study of models, whole mounts, and serial cross sections of various stages. The account of gastrulation in the chick follows those of Peters, Pasteels, and Spratt. A brief survey of the phylum chordata is presented in the fourth chapter, with emphasis on the evolutionary relationships of the different groups. A synoptic classification of the chordates is given at the end of the chapter.

Chapter five is devoted to a discussion of homology and recapitulation. The role of embryology in establishing homology is emphasized. Recapitulation is interpreted in genetic terms, with emphasis on the role of gene mutations and competition among genes.

A system-by-system examination of vertebrates in both adult and embryonic stages follows, beginning with a consideration of the skin and its products. The general plan followed is to present material relating to embryonic development and to the comparative anatomy of adult forms in sequence in the same chapter, or group of chapters, devoted to a particular system. In connection with material relating to embryonic development, directions are given for study and drawing of sections and whole mounts of chick and pig embryos. For the study of the anatomy of representative adult forms, directions are given for dissection of the dogfish, *Necturus*, and the cat. The nervous system and sense organs are taken up last (chapter 17), which may be justifiable from a practical point of view but is not consistent with their developmental history.

Gametogenesis and fertilization are taken up briefly in chapter fifteen, apparently being introduced at this time to follow study of the urogenital system in chapter fourteen. Only prepared slides of sections through the oviduct of *Ascaris* are indicated for use in the study of fertilization. It is unfortunate that directions for the utilization of appropriate living material have not been included. The subject matter of this chapter would seem more appropriately to follow chapter one. The various types of placenta are considered in chapter sixteen. Included here are directions for dissection of a pregnant sow's uterus.

The figures are generally adequate but undistinguished. Many of them are photographs made from material in routine use in the author's laboratory. Directions for drawing and dissections are sufficiently detailed to minimize the work of laboratory instructors. Laboratory directions are distinguished from text by appropriate section headings. Directions for drawing are prefaced by the word "draw" in bold-face type.

The most important contribution made by this book is the attempt to integrate the laboratory work of comparative anatomy and vertebrate embryology into a scheme suitable for use in an integrated course. It is pertinent to note that Washington University is not the only institution in which these subjects are now being taught in one and the same course. This manual, furthermore, reflects the current tendency to reduce the amount of time devoted to presenting descriptive aspects of biology and is designed to lend itself to courses of 100 to 120 clock hours of laboratory work.

Obviously, whether an integrated course in comparative anatomy and embryology is more successful in meeting student needs than separate courses in these subjects will depend in large part upon the ability of the instructor to carry the integration to the conceptual level. This is considerably more difficult than the grouping together of laboratory exercises. It is, perhaps, to be anticipated that some so-called integrated courses will be nothing more than a topical sequence telescoped into one-half or two-thirds the time that would otherwise be devoted to covering the same material. This in itself may not be undesirable, but would be considerably short of the intent of the author of this manual. Teachers who are interested in developing an integrated course in comparative anatomy and embryology will no doubt find the present manual very helpful.

MAX KRAUSS

VERTEBRATE EMBRYOLOGY. *Third Edition.*

By Robert S. McEwen. Henry Holt and Company, New York. $4.90. xvi + 699 pp.; ill. 1949.

The third edition of this textbook remains primarily descriptive, but certain results obtained from experimental procedures have been included in the sections dealing with the Amphibia and Chick. With respect to the latter, for example, recent findings concerning gastrulation are described, evidence for and against homology of the chick primitive streak and amphibian blastopore is presented. A section on the development of the pig has been added. Literature references are given at the end of each section, and there is an index.

MAX KRAUSS

FUNDAMENTALS OF COMPARATIVE EMBRYOLOGY OF THE VERTEBRATES. *Second Edition.*

By Alfred F. Huettner. The Macmillan Company, New York. $5.00. xviii + 309 pp.; ill. 1949.

In preparing this second edition of his textbook Huettner has undertaken a fairly extensive revision of certain portions of the first edition. New material, including a chapter on the embryology of the pig, has been added. As was true of the first edition, the most notable feature of this book is the three-dimensional character of the illustrations. In this respect, Huettner's textbook remains in a class by itself. The format is excellent. No list of references is given. There is an index.

MAX KRAUSS

AN INTRODUCTION TO VERTEBRATE EMBRYOLOGY. *Second Edition.*

By H. L. Wieman. McGraw-Hill Book Company, New York, Toronto, and London. $5.00. x + 412 pp.; ill. 1949.

In revising his textbook, Wieman has made a number of changes, mainly directed toward providing additional descriptive material on the frog, human embryology, and mammalian organogenesis. Some 40 new illustrations have been added. As in the first edition, the comparative point of view has been maintained. Certain aspects of experimental embryology, chiefly concerned with amphibian development, are briefly discussed in an appendix. This material might well have been given the status of a chapter. A short list of references, in connection with the appendix, is the only bibliography. There is an index.

Max Krauss

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La Science des Monstres. *L'Avenir de la Science—27.*

By Étienne Wolff. Gallimard, Paris. 580 fr. (paper). 265 pp. + 40 plates; text ill. 1948.

It is a peculiar and deplorable fact that no serious general treatise on teratology, the scientific study of monstrosities, has been published in the English language during the present century. With the exception of Schwalbe's encyclopedic work, which has shared the fate of many another German Handbuch of having become out of date before its final completion, the summarization of current knowledge has come almost exclusively from French writers: the two Saint-Hilaires, Dareste, Rabaud, and many others. To these is now added the present book by Étienne Wolff.

The author's aim was to write a survey, in simple language and for a wide audience, of the principal methods and problems of teratology. These aims, in part imposed by the fact that the book was written while the author was a prisoner of war, have been adhered to with great success. The result is a well illustrated text which lends itself admirably to an initial guidance through a complex and rapidly expanding field. The discussion is limited to vertebrate teratology. The original manuscript was completed in 1941, and an appendix was added in 1945. After a brief historical introduction, the book opens with a morphological account of the more common types of malformations. The first step in an analysis of malformations must always relate to their morphology, histology, and embryology. The author devotes one chapter to a presentation in these terms of selected cases, viz., ectromely, phocomely, anencephaly, coelosomy, and facial clefts. Wolff then gives a description of the techniques of experimental teratology. These are divided into *indirect* methods, applied to the egg or embryo as a whole, such as variations of the environmental temperature, mechanical shocks, or exposure to chemical agents, and *direct* methods, by which definite organ primordia are modified or eliminated with the aid of surgery and x-rays, transplanted to abnormal positions, or manipulated in other ways. One cannot agree here with the author's assumption that "indirect" methods necessarily produce their results by a modification of the general conditions of development, since there is evidence that their effects may be quite specific because of the selective susceptibility of particular parts.

The experimental production of twins and duplications is described in some detail. The following two chapters deal with various types of simple monsters, chiefly in chicken embryos, and with particular reference to the author's own beautiful experiments with x-rays. A negative aspect of the "direct" methods might have deserved some emphasis and discussion, namely, that they do not lend themselves to the production of teratological syndromes, such as are so generally brought about by genetic factors and environmental agencies.

The following chapter elaborates on the "laws of teratogenesis." Here there is much with which one cannot agree without strong reservations. Of these we can indicate but a few. According to the author's first law, the initial step of teratological development is always a localized arrest. There are too many exceptions to make this a safe generalization, e.g., the coexistence of duplications and defects in the "duplicate" mutation of the fowl, the possibility of inducing supernumerary organs (e.g., brain, Tamini), the effect of sex or other factors on the incidence of abnormalities, and so on. According to the author's second law, teratogenic factors act on the presumptive primordia between the moment of determination and that of differentiation. But there are cases in which an abnormality is known to begin during differentiation (insulin-induced micromelia) or even after its completion (brachymelia of rabbits); moreover, abnormalities may arise by a failure of determination to occur. Wolff's third law relates to the existence of differential susceptibility among embryonic tissues and is used to explain the origin of multiple abnormalities. It overlooks the fact that syndromes may arise because of differential needs of various parts, needs which in the presence of generalized metabolic disturbances cannot be met everywhere. Some other laws postulated by the author are less exceptional, but it is clearly too early to arrive at far-reaching generalizations concerning the universal origin of malformations.

Chapter 11 deals with spontaneous and experimental hermaphroditism, and chapter 12 with hereditary malformations. Additions in an appendix make it clear that at a later date the author would have discussed the problem of hereditary malformations differently and more extensively. A final chapter gives some general conclusions. Unhappily one cannot agree with the author that to know how to produce experimentally a particular malformation is tantamount to saying that its causes and mechanisms of formation have been explained. But such minor criticisms should not obscure the fact that the author has given us a very useful and valuable book.

Walter Landauer

WOMAN'S INSIDE STORY.

By Mario A. Castallo and Cecilia L. Schulz. The Macmillan Company, New York. $3.00. xii + 203 pp.; ill. 1948.

A practising gynecologist and a nurse have pooled their experiences and talents in preparing this instructive and authoritative story of the development, structure, and function of the female reproductive system. Written in a clear, and simple fashion for popular consumption, the work is designed not only to impart knowledge, but to develop wholesome attitudes toward sex and the reproductive process. Particular emphasis is placed on the plea for women to give as much concern and care to their internal health or ailments as they give to their external appearance.

The discussions are centered largely around normal reproductive development and physiological activity from the time of conception of the individual, through fetal life to birth, and from thence through childhood, adolescence, and menarche, the reproductive span, the menopause, and on to senescence. Byways from this general scheme lead into detailed considerations of such topics as sterility, tumors, and pregnancy. Sufficient material on physiological abnormalities is included to give the average reader ample clues to the fact that some part of her reproductive system may need medical attention. Encouragement is given to the idea of routine physical examinations for health maintenance, in opposition to the idea that the doctor should only be seen when something goes wrong. Considerable effort has been expended to debunk many of the old wives' tales concerning pregnancy and child-birth and to tear down the barriers of fear and false modesty which have been largely responsible for keeping women "in the dark" concerning their own "inside story." A careful reading of the book would undoubtedly improve the outlook on life of countless women, of all ages from 16 to 60. A glossary and an index contribute much to the value of the work as a source of reference.

B. AUBREY SCHNEIDER

ANIMAL MORPHOLOGY

BIOLOGY OF THE VERTEBRATES: *A Comparative Study of Man and His Animal Allies. Third Edition.*

By Herbert E. Walter and Leonard P. Sayles. The Macmillan Company, New York. $6.00. xx + 875 pp. + 1 plate; text ill. 1949.

This book, now in its twenty-second year, has reached its legal majority—no mean achievement for a biological textbook. Unlike many people, the book retains most of the whimsical ways of its childhood.

As nearly everyone must know by this time, Walter's *Biology of the Vertebrates* is not a biology of the vertebrates. Nor is it the textbook of comparative anatomy that it superficially appears to be. It is designed quite frankly to ease young premedics into the work they will shortly be taking in medical school. It does an efficient and almost painless job, which doubtless explains its continuing popularity.

Sayles has reworked several of the chapters extensively, but the peculiar flavor of the earlier editions has been carefully preserved. More than half the illustrations have been redrawn and more fully and uniformly labeled, and many new illustrations have been added. Some will miss a few illustrations, like Raphael's cherubs and the cartoon-like "hatching dinosaurs," that may not have added much to the text but helped to lighten a subject that all too easily becomes dull and ponderous. The general format of the book has been modernized, and the page size slightly increased. So has the price. Many additional years of useful life may be predicted for this standard textbook.

D. DWIGHT DAVIS

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COMPARATIVE ANATOMY: *An Introduction to the Vertebrates.*

By Leverett A. Adams and Samuel Eddy. John Wiley & Sons, New York; Chapman & Hall, London. $5.00. viii + 520 pp.; ill. 1949.

Many biologists maintain that comparative anatomy is moribund as a science, and that the only decent thing for it to do would be to expire peacefully and submit to a proper burial. D. M. S. Watson, himself a comparative anatomist of note, described comparative anatomy in the 14th edition of the *Encyclopedia Britannica* as "a term, now obsolescent. . ." Proponents of these views (not shared by the reviewer) will find potent support for their arguments in this textbook, which is no worse than others in the English language and better than many.

The authors divide the indivisible vertebrate body into the usual mutually exclusive morphological "systems," and then proceed to a dreary recital of facts—450 grim pages of them. The ultimate in fragmentation is achieved by dividing the description of each system into a series of air-tight compartments labeled, respectively, Fishes, Amphibians, Reptiles, Birds, and Mammals. It is inconceivable that a student could be inspired by such a parade of unrelieved and unrelated details.

What is wrong that we have so sorry a textbook in a field as old and mature as comparative anatomy? The book is reasonably accurate, profusely illustrated, and is supplied with a glossary and an index running to 28 pages each, and a bibliography. In physical appearance it is admirable, but as a presentation of the science of comparative anatomy it is a libel. The authors state (p. 105) that "comparative anatomy is a more dynamic approach to the study of anatomy than the mere learning of the location and structure of organs and systems," but this obviously crept in by mistake. Science is usually defined as the classification of facts *and the generaliza-*

tions derived therefrom. The present book is about as free of generalizations as is possible. Even homology, the broad generalization on which comparative anatomy is founded, is slurred over in two short paragraphs. Evolution, the most sublime of all biological generalizations, and indissolubly associated with comparative anatomy from the very beginning, is not even listed in the index! A science that is merely a recital of facts is not only dull and uninteresting; it is not even a science, but only the raw material from which a science can be built.

The few surviving comparative anatomists will probably weep alone at this travesty on their science. But the real impact of such tragically inadequate textbooks is on biological research as a whole. If generations of biological researchers—to say nothing of teachers of further generations—are to grow up in ignorance of the real meaning of comparative anatomy, then the whole framework of biological science is weakened by just that much.

What would be a good textbook of comparative anatomy? It surely would review the several outstanding contributions that comparative anatomy has made to biological theory. It would stress the intimate relations between structure and function that make comparative anatomy meaningful. It would be guided throughout by the important distinction between the biological and other sciences—the fact that living organisms, without exception, have been conditioned by the vicissitudes of their respective histories. Some biologists, in their zeal to get at the fundamentals of biology, forget this most fundamental of all biological facts. And finally it would remind the student, repeatedly, that comparative anatomy is not finished, but that important and exciting discoveries are still to be made.

There is no point in inveighing against geneticists, embryologists, physiologists, and others for failing to recognize that comparative anatomy is not dead. It is the comparative anatomists themselves who are responsible for the delinquency of comparative anatomy. I specifically charge this book with contributing to the delinquency of a science.

D. Dwight Davis

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The Vertebrate Body.

By Alfred Sherwood Romer. W. B. Saunders Company, Philadelphia and London. $5.50. viii + 643 pp.; ill. 1949.

The teaching of comparative vertebrate anatomy has long suffered from the lack of a truly adequate modern textbook written in the English language. This statement is made with full cognizance that there are adequate and excellent textbooks in the traditional manner. But in these little or no attention has been paid to cognate sciences such as physiology, experimental embryology, and genetics, so that they are essentially anatomical or morphological in the narrower sense, too often in the moribund Gegenbaurian tradition. And, moreover, too many comparative-anatomical textbooks have been written by people who were not professionals in that field and who consequently have had no real knowledge of the true comparative method.

In the opinion of the reviewer, Romer has at last supplied us with a truly adequate book, in fact with a superior one that may play a considerable role in the rehabilitation of this branch of biology. As has been pointed out elsewhere, comparative anatomy, if it is to recover lost ground and to prosper, must become broader in scope—in fact, it must become a comparative biology in place of the narrower, traditional comparative anatomy or morphology. Romer's book meets this demand. In his introductory Apologia he lists six desiderata for the adequate comparative text: "1. Fairly adequate illustration.... 2. A truly comparative treatment.... 3. Proper paleontological background.... 4. A developmental viewpoint.... 5. Inclusion of histological data.... 6. Consideration of function." The body of the text reflects this point of view. The illustrations in general are first-rate, being neither too schematic nor overcrowded with details. The treatment of the body is truly comparative, human structure not being overemphasized but presented in its proper perspective. If the reviewer can find any fault, it is with the tendency toward an overemphasis of the reptiles, and to a less extent the fishes, with accompanying neglect of the amphibians. That there is proper and adequate paleontological background goes without saying, for the accomplishments of the author would guarantee that. If anything, one may feel at times that this aspect of the subject is a bit overdone—but every textbook necessarily reflects the interests of its author, and rightly so. Indeed, the presentation of the fossil evidence represents one of the most brilliant and stimulating aspects of the book. The embryology is comprehensive and takes cognizance of the contribution of the experimental method. That the included histology is largely mammalian merely reflects the gaps in our knowledge and at the same time points up one of the most promising fields for comparative study, especially if morphological methods are combined with those of physiology and chemistry. The frequent sections on physiology are concise, yet extraordinarily well done, and make amends for the "dead-house" treatment of the vertebrate body that is predominant in current courses on comparative vertebrate anatomy.

The book is so uniformly excellent that to single out separate parts is perhaps unjustifiable. But it may be noted that such subjects as "the homology concept," "adaptation and evolution," the relationship between ontogeny and phylogeny, "the germ layers," and nerve-muscle relationship receive wholly modern treatment without the lingering traces of Owenism, Lamarckism, Haeckelism, and Fürbringerism so often found in other books. The chapters that deal with the skeleton are superior in quality. Those on the nervous system and the sense organs are among the best to be found in books of this sort. The muscular system, a subject that presents great difficulties of treatment and that is consequently badly dealt with or else grossly neglected in most comparative-anatomical texts, is handled, for the most part, with great skill—which reflects Romer's recognized status as an outstanding comparative myologist.

It has been a great pleasure to review this book. For, in the opinion of the reviewer, it is without serious defects. To dwell upon its minor errors and its treatment of certain controversial points would be to cavil, indeed. It is not only authoritative, but well written and easy to read, in addition. It should go a long way toward advancing the cause of comparative biology in this country.

William L. Straus, Jr.

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Bensley's Practical Anatomy of the Rabbit: *An Elementary Laboratory Text-Book in Mammalian Anatomy. Eighth Edition.*

Revised and edited by E. Horne Craigie. The Blakiston Company, Philadelphia. $4.25. xii + 391 pp.; ill. 1948.

A number of small changes and additions have been made in the present revision of this well-known elementary laboratory textbook on the anatomy of the rabbit. Among other additions, there is a new section on fetal circulation. The chapter on General Anatomy and the section on the description of the larynx have been expanded a little. Some new illustrations have been added and some old ones replaced by new photomicrographs.

David B. Tyler

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Collateral Circulation: *Anatomical Aspects.*

By Daniel P. Quiring; illustrated by Margaret Holman. Lea & Febiger, Philadelphia. $5.00. 142 pp.; ill. 1949.

Quiring here presents the anatomy of the arterial and venous bypaths that develop on occlusion of major vessels, and reviews certain aspects of their physiology. In so far as the book describes the topography of these vascular pathways, it is concise and well-informed, but where it becomes theoretical it is frequently poorly digested and unclear.

The book consists of 128 pages of text and excellent illustrations, plus a carefully selected bibliography and a good index. The contents include a brief historical review that shows clearly how much of the work on circulation is not modern; a descriptive embryology relating how primitive vascular networks become differentiated in the early development of the individual; a discussion of vascular dynamics; and a well conceived regional presentation of the major collateral pathways, both arterial and venous.

The material is presented in such form that specific information can be located easily, and there are no large gaps in either the classical or recent descriptions of collateral routes. The inclusion of recent information is well typified by the generally excellent treatment of the collateral coronary circulation. Practical illustrative material is inserted from time to time. The unusually readable type, clear illustrations, and pleasant format are also deserving of comment.

In general, where the literature is reviewed, the author has failed to correlate information in the papers of various writers and has presented insufficient material to provide a basis of judgment for the reader. Certain physiological concepts are confusingly presented. As a specific example, the limitations in the applicability of the 4th power law (Poiseuille's law) are not made clear, despite the fact that this principle holds only for small tubes where the viscosity of the contained fluid is an important factor in the rate of flow. It is unfortunate also that the various concepts of the term "end artery" are not defined. *Collateral Circulation* should prove to be a useful reference book for anatomists and surgeons, and in addition it is interesting enough to attract students and should attain a considerable popularity.

E. Converse Peirce, 2nd

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Surgical Technique and Principles of Operative Surgery. *Fourth Edition.*

By A. V. Partipilo; foreword by Alton Oschsner; original illustrations by W. C. Shepard and Hooker Goodwin. Lea & Febiger, Philadelphia. $15.00. 676 pp.; ill. 1949.

Surgical Technique, as presented by Partipilo, is well grounded in the basic disciplines of anatomy, pathology, and physiology, but despite its stated purpose to provide a "practical reference text for the surgeon," it constitutes primarily an approach to surgery for the student. There is great emphasis on fundamentals of technique, with chapters on suture material and knot-tying. Anatomy is well represented, with individual sections devoted to the abdominal wall and the peritoneal cavity.

In general, the book is more restricted than most textbooks of operative surgery. The author has provided thirty chapters on general principles, the stomach, duodenum, small intestine, breast, and thyroid gland, and some of these subjects have been given disproportionate emphasis. The remaining twenty-three chapters, by eight authors, cover the thorax, biliary passages, large bowel, anus and rectum, kidney, peripheral vascular disease, facial injuries, and blood transfusions. There are many large gaps, and much of the material not written by Partipilo is too briefly covered to be of use to any but the casual reader. It is unfortunate also that the most complete chapters have the best bibliographies, while the briefest have none. Cardiac surgery, for instance, is dispensed with in four pages without references, though the twenty-one page chapter on duodenal obstruction has fifty-one references.

The main body of the book is well written and sensible. Generally only one surgical method is presented in detail. The text is greatly enhanced by the unusually fine line drawings of W. C. Shepard and Hooker Goodwin. Partipilo's book can be highly recommended to students and practitioners seeking an approach to surgery, but it will prove a disappointment to those who desire a complete coverage of the field.

E. CONVERSE PEIRCE, 2ND

ANIMAL PHYSIOLOGY

RESPIRATORY ENZYMES. *Second Edition.*
By Laurens Anderson, Robert H. Burris, Phillip P. Cohen, C. A. Elvehjem, M. J. Johnson, Henry A. Lardy, G. A. LePage, Henry Little, R. W. McGilvery, W. H. McShan, G. W. E. Plaut, Van R. Potter, W. C. Schneider, and P. W. Wilson; edited by Henry A. Lardy. Burgess Publishing Company, Minneapolis.
$4.50. iii + 290 pp.; ill. 1949.

This is an excellent textbook covering the subject of the respiratory enzymes and, like the first edition, will be of special interest to the investigator in the field of enzymology. In essence, this revision was made in order to include the most recent developments in the field and to delete much that has become obsolete. The text opens with an excellent historical treatment of the subject (C. A. Elvehjem), and is followed by sections dealing with such subjects as the Kinetics and Mechanisms of Enzyme Reactions (P. W. Wilson); Oxidation-Reduction Potentials (Marvin J. Johnson); Table of Oxidation-Reduction Potentials (Laurens Anderson and G. W. E. Plaut); Coenzymes and Activators (G. A. LePage); Dehydrogenases (W. H. McShan); Cytochrome Systems (Van R. Potter); Oxidases, Peroxidases, and Catalase (R. H. Burris and Henry N. Little); Glycolysis (Henry A. Lardy); The Citric Acid Cycle and the Cyclophorase System (David E. Green); Enzymatic Systems Concerned with the Metabolism of Certain Nitrogen Compounds (Phillip P. Cohen and Robert W. McGilvery); Energy Relations in Metabolic Reactions (Marvin J. Johnson); The Control of Metabolism (Van R. Potter); and the Distribution of Enzymes Within the Cell (Walter C. Schneider).

DAVID B. TYLER

MANOMETRIC TECHNIQUES AND TISSUE METABOLISM.
By W. W. Umbreit, R. H. Burris and J. F. Stauffer; chapters on specialized techniques by P. P. Cohen, G. A. LePage, V. R. Potter, and W. C. Schneider and contributions by J. A. Bain, D. E. Green, H. A. Lardy, A. L. Lehninger, R. W. McGilvery, and R. Wennesland. Burgess Publishing Company, Minneapolis.
$4.00. v + 227 pp.; ill. 1949.

This edition of this useful and practical manual is a considerable improvement over the first. It has been very extensively revised and rearranged, and many new figures and charts have been added. The tables have been reset, improving not only their appearance but also their readability. As in the first edition, there will be found chapters on Specialized Techniques by P. P. Cohen, G. A. LePage, V. R. Potter, and W. C. Schneider. Other contributors to this edition are: J. A. Bain, D. E. Green, H. A. Lardy, A. L. Lehninger, R. W. McGilvery, and R. Wennesland. The chapters on chemical and special methods have been expanded to include a number of new and valuable techniques which have recently been developed. A short section on the use of isotopic tracers in the Warburg apparatus has been included, with suggestions as to how such procedures may be applied to the study of enzymatic reactions. However, since it fell outside the scope of this book, no detailed consideration has been given to the instrumentation and techniques involved in the use of isotopic tracers. An extensive section by R. Wennesland, describing volumetric apparatus for the study of tissue metabolism, and one by D. E. Green on the preparation of cyclophorase have been added to this edition. There is also an entire new chapter by W. C. Schneider on the isolation of particulate components in the cell. Practically all of the chapters have been very thoroughly revised, and the book is now bound with a hard, durable cover which will improve its usefulness in the laboratory. For subsequent editions, it is suggested that the index be expanded to include an author's index. This manual will undoubtedly be a valuable addition to the personal library of all those who are interested in problems of tissue metabolism. It will also serve as a laboratory companion to *Respiratory Enzymes*, reviewed in this journal on p. 97.

DAVID B. TYLER

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A TEXTBOOK OF PHYSIOLOGY. *Sixteenth Edition.*
Edited by John F. Fulton; with the collaboration of Donald H. Barron, John R. Brobeck, Robert W. Clarke, George R. Cowgill, Paul F. Fenton, William U. Gardner, Samuel Gelfan, David I. Hitchcock, David P. C. Lloyd, Leslie F. Nims, Theodore C. Ruch and Jane A. Russell; originally by William H. Howell. W. B. Saunders Company, Philadelphia and London.
$10.00. xl + 1258 pp.; ill. 1949.

This volume in its 16th Edition (the second revision by John Fulton and his collaborators) ranks among the very few truly excellent physiological textbooks. Since this edition, compared with the 15th published 3 years ago, has been rather extensively revised and rewritten, this review will deal with major changes. The 15th Edition has been adequately reviewed in Q. R. B. *21:* 200. 1946.

The text is now divided into thirteen principal divisions, instead of the ten found in the 15th Edition. The most extensive addition is the inclusion of a much needed division on Endocrines, prepared by Jane Russell. A separate division on Muscle has been prepared by Samuel Gelfan, thus leaving to David Lloyd the responsibility for the chapters dealing with the principles of nervous activity. (In the 15th Edition, Lloyd covered both Muscle and Nerve.) Another addition is a contribution by T. C. Ruch on the Urinary Bladder. The division on the Central Nervous System has been shortened by about 40 pages through deletion of obsolete material, both in text and illustrations. J. R. Elkinton has rewritten the chapter on the Kidney, and R. B. Livingston has contributed a section on the Cerebrospinal Fluid. The chapter on the genetic aspects of physiology has been dropped. In preparing this edition there has been some departure from the simple and lucid style of Howell. Nevertheless, the book is still one of the very few major textbooks suitable for use by advanced students of physiology.

David B. Tyler

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An Introduction to Gastro-Enterology. *Fourth Edition.*

By Walter C. Alvarez. Paul B. Hoeber, Medical Book Department of Harper & Brothers, New York. $12.50. xxiv + 903 pp.; ill. 1948.

Since 1922, *An Introduction to Gastro-Enterology* has been the standard source book in its field, and deservedly so. This edition maintains the standard set by the three previous ones. The bibliography has been increased by twenty-five per cent, to include 2800 titles. The subjects most extensively modified are those concerned with the innervation of the gastro-intestinal tract, the functions of the colon, the electro-enterogram, and with technical methods and apparatus. In all of this, the hand of an old master in the field is evident. The reader knows that the evaluations made are the result of a very extensive laboratory and clinical experience indeed.

The mark of the earlier editions is still very evident. From the outset, and recurrently, the subject of the existence, mechanism, and functions of gradients of intestinal activity are assessed and stressed. It is the dominant theme in the discussion of normal and abnormal intestinal activities. The author has drawn heavily upon ancillary fields in biology in efforts to clarify all points. This is stimulating to the inquisitive reader, and it challenges the imagination. One recognizes over and over again how elusive a thing an absolute understanding of a biological function is! To explain one process by a similar process involves a semantic tautomerism which leaves one wondering, What is the beginning and where is the end?

The volume is large, well-printed, and handsomely illustrated. Only the index is brief and inadequate. The inclusion of photographs of numerous workers, past and present, who have made important contributions in the field is, one feels, incomplete: modesty forbidding the inclusion of a picture of Alvarez himself. This volume is so extensive, so sound, and so valuable that the reader will feel he has been denied a privilege in not seeing in this gallery the author's picture along with the rest.

S. R. M. Reynolds

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Secretion of Milk. *Third Edition.*

By Dwight Espe. The Iowa State College Press, Ames. $3.50. viii + 314 pp.; ill. 1946.

This book represents fifteen years' collection of material for the teaching of a college course in milk secretion. A very large amount of information is presented in brief form. The book consists of three parts. The first part covers the phylogenesis of the mammary gland and the anatomy of the udder. The author is very modest, stating in the preface that he "may have failed to grasp the true significance of the work which has been reported." His point of view is obviously that of a searcher among the research results of the physiologist, anatomist, and nutritionist for facts which may be pertinent in understanding why and how cows secrete milk. The narrowness of the account is somewhat exaggerated by the author's not wholly acceptable statement: "The mammary glands of many mammals, especially domesticated mammals, are interesting from a scientific view, but in America at the present time the practical importance of the milk of the cow makes a knowledge of her udder more important than an understanding of that of any other species."

Part Two consists of four chapters. The chapter on nervous control of milk secretion is rather confusing. The chapter on the factors affecting the amount and composition of milk, including the effects of age, season, reproductive state, and inheritance is well done. The review of hormonal control of milk secretion is lucid and effective. Espe properly concludes, however, that "the practical significance of the many recent discoveries in endocrinology can only be surmised." The third part of the book summarizes research on the effects of feed on the amount and composition of milk. The literature cited consists of 1294 titles.

T. C. Byerly

Endocrinologie des Arthropodes. *Colloques Internationaux du Centre National de la Recherche Scientifique, IV. Paris, Juin 1947.*

Centre National de la Recherche Scientifique, Paris. 1000 fr. (paper). 213 pp. + 1 plate; text ill. 1949.

This report on the International Colloquium on the Endocrinology of Arthropods, held in Paris in June, 1947, and published as Supplement XXXIII to the *Bull. biologique de France et Belgique*, contains the following papers: The Retrocerebral Endocrine Glands of Insects (Cazal); The Hormonal Control of Moulting and Metamorphosis in Insects (Wigglesworth); Determinism of Metamorphosis in Lepidoptera (Bounhiol); The Endocrinology of Diapause (Williams); The Reactions of Crustaceans to Insect Hormones (M. Thomsen); An Experimental Study of the Metamorphosis of *Sialis lutaria* L. [Megaloptera] (Geigy); The Gonadotropic Hormones in the Diptera (E. Thomsen); The Sexual Hormones of Insects (Joly); The Chemistry of Insect Hormones (Timon-David); Brain Centers and Incretory Organs in the Head of Crustacea Malacostraca (Hanström); Migrations of the Retinal Pigments and Their Regulation by the Sinus Gland (Kleinholz); Colour Change and Colour Hormones in Crustaceans (Carstam); The Problem of the Number of Hormones Concerned in the Pigment Movements of Crustaceans (Knowles); The Sinus Gland and the Maturation of Genital Products in Shrimps (Panouse); The Sinus Gland, Moulting, and Metabolism in Crustaceans (Drach); General Report on the Endocrinology of Insects (Wigglesworth); General Report on the Endocrinology of Crustaceans (Drach); and Three Principal Incretory Organs in the Animal Kingdom (Hanström).

The Adrenal Gland.

By Frank A. Hartman and Katharine A. Brownell. Lea & Febiger, Philadelphia. $12.00. 581 pp.; ill. 1949.

This book is a timely and substantial compendium of research on the adrenal gland. The authors have attempted to treat all phases of the subject. To summarize a field as active as that of the adrenal, which at present seems to be exploding in all directions, is indeed an ambitious task. The book includes some discussion of the anatomy, histology, development, biochemistry, physiology, pathology, and diseases of the adrenal, with chief emphasis on physiology. Of thirty-four chapters, six are concerned with epinephrin and medullary function, thirteen with the physiology of cortical function, chiefly in relation to electrolyte and water exchange, energy metabolism, and endocrine interrelationships, and eight with adrenal diseases. It contains an impressive bibliography of well over 3000 references, but no date on which the bibliography was closed. The material has not been particularly well organized, treatment is sometimes perfunctory, and not free from contradictions. It does not present any outstanding syntheses, nor on the other hand any pretentious guess work. It does constitute an assemblage of the outcome of a vast number of physiologist-hours, and will be useful as a work of reference for the specialist. However, the treatment of any subject is seldom intensive enough to be more than a first approach to it. In effect, the book has not surmounted the contemporary Sturm und Drang in endocrinology, which as many of us believe, can probably only be ordered in a satisfactory and enduring sense by the gradual development of a theoretical chemistry of life processes.

As a conscientious summation, this is of necessity a book which faces largely toward the past—a past where physiology has been hewing the wood and drawing the water of primitive first approximations, rather than toward the future of an adrenal physiology attuned to the music of the molecules.

Evelyn Howard

Electrocardiographic Technique. *A Manual for Physicians, Nurses and Technicians.*

By Kurt Schnitzer. Grune & Stratton, New York. $3.50. 96 pp.; ill. 1949.

This little book deals exclusively with electrocardiographic technique, and is intended particularly for the technician not trained in the field of electrocardiography. The manual covers the following topics in a clear and concise manner: The Human Heart; The Electrocardiographic Machine; The Electrocardiographic Room and Preparation of the Patient; The Recording of the Electrocardiogram; The Standardization of Precordial Leads; Special Procedures and Devices; Distortion of the Electrocardiograph and its Elimination; Finishing of the Record; and Mounting and Filing. Although there is no attempt to instruct the reader in the interpretation of records, some consideration is given to a few patterns that can be mistaken for artefacts. The style of writing is simple and lucid. It is excellently illustrated with original drawings and photographs and contains an adequate bibliography and index. This sound little book should prove a very useful addition to the personal library of nurses and technicians.

David B. Tyler

Die Elemente der nervösen Tätigkeit.

By A. E. Kornmüller. Georg Thieme Verlag, Stuttgart. RM 13.50 (paper). viii + 120 pp.; ill. 1947.

This review monograph is an interesting attempt to correlate the structure and chemical constitution of nervous tissue with its functional activity. Principal attention has been given to the "neurone theory" and the synapse problem, and various points of view are presented. As in all previous attempts to reconcile the findings and concepts of the "neuronists," who see no evidence of any continuity of neurofibrils from cell to cell in synaptic areas, and of those who advocate a syncytial doctrine of nerve cell, and neuroglial, structure, the choice is finally made well to one side of the middle. A novel twist is added, however, in that neurofibrils are represented as showing discontinuity, but as ending, nevertheless, *within* the cell of termination. Unfortunately, original evidence for the intracellular location of the synapse is not offered, nor is the evidence of the older syncytialists marshalled in a convincing way. In the reviewer's opinion, however, credit is due the author for giving the non-neuronal elements of the nervous tissue more attention than is customary, although a really useful working hypothesis of their function does not appear to be offered.

DAVID BODIAN

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CHEMICAL INSECT ATTRACTANTS AND REPELLENTS.

By Vincent G. Dethier. The Blakiston Company, Philadelphia and Toronto. $5.00. xvi + 289 pp.; ill. 1947.

The main purpose of this book is to bring together from a scattered literature in several fields the information which will contribute to an understanding of the chemical, physical, biological, and physiological factors which underlie the effectiveness of attractants and repellents. For its contributive significance in relation to this purpose much information has been furnished regarding the substances and devices that contribute to insect control, and those to whom these aspects are of primary concern are referred to the several detailed discussions of these matters. Similarly, although chemoreception is the fundamental basis underlying the stimuli and responses involved in the action of attractants and repellents, the book is not intended as a comprehensive treatment of chemoreception per se. Rather, the book effectively furnishes a comprehensive insight into insects' chemoreception as fundamental behavior on which practical procedures and further research may be based. As a result, the author's main purpose is achieved with notable success, and the book is a highly enlightening, interpretive, and stimulating volume of far wider interest and significance than its title might indicate.

It is clear that the author hopes that better understanding of the basic aspects of attractants and repellents will contribute to the knowledge of insect behavior and ecology, and even to a better understanding of the evolution of certain of their habits and behavior patterns. It is clear also that the author hopes that the book may lead to work that will contribute to our knowledge of the host-parasite relations and food-plant preferences of insects, and also to a fuller understanding of the bases of physiological races among the insects. Within the 289 pages of this compact book are contained the interpretation and evaluation of a tremendous amount of significant but scattered literature, together with much original work by the author, whose outstanding contributions in the investigation of the essential bases of selection of food plants by insects preeminently qualifies him to write this treatise.

In type and format the book is attractive. The illustrations are excellent and effectively supplement the text. Since the chapters cover fields which are necessarily diverse, although essential to the fundamental plan of the work, the lists of pertinent literature are placed at the end of each chapter. While this arrangement inevitably involves some repetition, it is highly helpful to the reader.

The general plan of organization followed in the book is an effective one. After a Preface of 2½ pages in which the objectives and the fundamentals of the book are set forth, there is a brief Foreword by Professor Brues, emphasizing the extensive ramifications and the significant implications to be derived from the basic physiological theme of the relation of the senses of smell and taste to the behavior of insects. The first chapter, after a historical background and a definition of the terms attractant and repellent, points out that the stimuli involved are fundamentally chemical in nature. The major types of physical stimuli are then briefly discussed in their relation to these. In the second chapter, the nature of chemical attractants is considered in detail. Here is clarified the fundamental fact that odors alone are involved in the chemical attractants, while both odors and tastes may serve as repellents, through calling forth simple avoiding reactions. Although this chapter emphasizes the two great classes of attractants, those which direct the insect to suitable sites for laying eggs and those which direct it to its food, there are also excellent discussions of other attractants, such as the sex scents which result in spectacular assembling, and the recognition odors so important among social insects. After a comprehensive consideration of the attractants for oviposition, there follows a survey of the attractants which direct insects to their food, with a discussion of the classificational schemes by which insects may be grouped according to their feeding habits. Finally, the author notes the three well-defined groups into which the chemical food type of attractants falls, and briefly outlines these as the categories which are to be examined in detail in the three comprehensive chapters that follow.

Chapter 3, on the essential oils, resins, and related substances which are the fundamental plant products attracting insects that feed on leaves, flowers, fruits, wood, and sap, is a highly effective treatment of 35 pages, with a summarizing discussion and extensive bibliography. Here is brought together the pioneer work of the author himself and of other investigators of this fascinating field, work that effectively substantiates the final conclusion that the so-called botanical sense of insects, which governs their relation to certain taxonomic groups of plants, basically depends on the presence of these substances.

Chapter 4 discusses in detail the products of fermentation, such as alcohols, acids, aldehydes, esters, and carbinols, which direct the carpophagous, xylophagous, mycetophagous, and sap-feeding insects. Information of a fundamental chemical nature explains the basis of the attractants for such destructive insects as the fruit moths and fruit flies, the codling moths and borers. The discussion brings out the interesting points that insects attracted by products of fermentation are not rigidly specific in their feeding habits, and hence that many insects whose life activities have no relation to natural fermenting materials may be lured by such attractants. It further clarifies the fact that products of fermentation serve primarily as feeding-type attractants, and serve secondarily, and for relatively few insects, as attractants for suitable sites for egg-laying.

Chapter 5 (36 pages) furnishes a detailed discussion of the fundamental products of protein and fat decomposition, emphasizing the fatty acids, amines, ammonia, carbon dioxide, and other products which attract many types of insects to diverse decaying natural substances. Chapter 6 furnishes a very valuable survey of the work which has been done by means of olfactometers to determine with precise quantitative accuracy the attractive or repellent properties of various materials. The discussion of the advantages and disadvantages of various types of olfactometers gives helpful understanding of experimental procedures by which dependable information has been obtained, and furnishes the investigator with the understanding and implementation on which such work must be based. While this chapter is especially useful for the research worker, yet it is also of general value in furnishing the fundamental knowledge and understanding on which an evaluation of such work must depend. Chapter 7, in its interpretive consideration of baits and traps, contrasts the empirical procedure of testing hundreds of miscellaneous chemical compounds with the more logical procedure of applying the fundamental principles of an understanding of chemoreception in insects to obtain more effective practical results. The importance of the feeding-type of attractants is stressed, as is the importance of investigating those types of compounds which meet the preference of insects for certain molecular combinations and concentrations; and the relation of these more fundamental factors to specific problems in trapping is effectively exemplified.

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The two aspects of the work which impress this reviewer particularly are first, the diverse and numerous aspects of biology, in its broadest sense, on which the contents of this book have significant bearing; and second, the wealth of fascinating problems which positively plead for investigation as a result of the provocative questions brought up in every chapter of this stimulating book.

W. H. WESTON

* * *

THEORY OF HEARING.

By Ernest Glen Wever. John Wiley & Sons, New York; Chapman & Hall, London. $6.00. xiv + 484 pp.; ill. 1949.

The author has divided this book into three sections. The first section presents an historical treatment of the classical theories of hearing, from the days of the Greek philosophers up through the early part of the twentieth century. The second section deals with the modern developments of these theories, and includes some of the anatomical and neurophysiological data pertinent to these developments. The third, and largest section, presents the author's own theory, and relates his theory to the neurology and psychophysical data of hearing.

The history of auditory theory is an excellent presentation, and should be required reading for all students in the field of hearing. The development of the sequences of ideas, and the relatedness of various theories is very well handled. Likewise, when the author is dealing with factual data in the area of anatomical and neurophysiological data, he is at his best. When, presented. As in all previous attempts to reconcile the findings and concepts of the "neuronists," who see no evidence of any continuity of neurofibrils from cell to cell in synaptic areas, and of those who advocate a syncytial doctrine of nerve cell, and neuroglial, structure, the choice is finally made well to one side of the middle. A novel twist is added, however, in that neurofibrils are represented as showing discontinuity, but as ending, nevertheless, *within* the cell of termination. Unfortunately, original evidence for the intracellular location of the synapse is not offered, nor is the evidence of the older syncytialists marshalled in a convincing way. In the reviewer's opinion, however, credit is due the author for giving the non-neuronal elements of the nervous tissue more attention than is customary, although a really useful working hypothesis of their function does not appear to be offered.

DAVID BODIAN

* * *

CHEMICAL INSECT ATTRACTANTS AND REPELLENTS. *By Vincent G. Dethier. The Blakiston Company, Philadelphia and Toronto.* $5.00. xvi + 289 pp.; ill. 1947.

The main purpose of this book is to bring together from a scattered literature in several fields the information which will contribute to an understanding of the chemical, physical, biological, and physiological factors which underlie the effectiveness of attractants and repellents. For its contributive significance in relation to this purpose much information has been furnished regarding the substances and devices that contribute to insect control, and those to whom these aspects are of primary concern are referred to the several detailed discussions of these matters. Similarly, although chemoreception is the fundamental basis underlying the stimuli and responses involved in the action of attractants and repellents, the book is not intended as a comprehensive treatment of chemoreception per se. Rather, the book effectively furnishes a comprehensive insight into insects' chemoreception as fundamental behavior on which practical procedures and further research may be based. As a result, the author's main purpose is achieved with notable success, and the book is a highly enlightening, interpretive, and stimulating volume of far wider interest and significance than its title might indicate.

It is clear that the author hopes that better understanding of the basic aspects of attractants and repellents will contribute to the knowledge of insect behavior and ecology, and even to a better understanding of the evolution of certain of their habits and behavior patterns. It is clear also that the author hopes that the book may lead to work that will contribute to our knowledge of the host-parasite relations and food-plant preferences of insects, and also to a fuller understanding of the bases of physiological races among the insects. Within the 289 pages of this compact book are contained the interpretation and evaluation of a tremendous amount of significant but scattered literature, together with much original work by the author, whose outstanding contributions in the investigation of the essential bases of selection of food plants by insects preeminently qualifies him to write this treatise.

In type and format the book is attractive. The illustrations are excellent and effectively supplement the text. Since the chapters cover fields which are necessarily diverse, although essential to the fundamental plan of the work, the lists of pertinent literature are placed at the end of each chapter. While this arrangement inevitably involves some repetition, it is highly helpful to the reader.

The general plan of organization followed in the book is an effective one. After a Preface of 2½ pages in which the objectives and the fundamentals of the book are set forth, there is a brief Foreword by Professor Brues, emphasizing the extensive ramifications and the significant implications to be derived from the basic physiological theme of the relation of the senses of smell and taste to the behavior of insects. The first chapter, after a historical background and a definition of the terms attractant and repellent, points out that the stimuli involved are fundamentally chemical in nature. The major types of physical stimuli are then briefly discussed in their relation to these. In the second chapter, the nature of chemical attractants is considered in detail. Here is clarified the fundamental fact that odors alone are involved in the chemical attractants, while both odors and tastes may serve as repellents, through calling forth simple avoiding reactions. Although this chapter emphasizes the two great classes of attractants, those which direct the insect to suitable sites for laying eggs and those which direct it to its food, there are also excellent discussions of other attractants, such as the sex scents which result in spectacular assembling, and the recognition odors so important among social insects. After a comprehensive consideration of the attractants for oviposition, there follows a survey of the attractants which direct insects to their food, with a discussion of the classificational schemes by which insects may be grouped according to their feeding habits. Finally, the author notes the three well-defined groups into which the chemical food type of attractants falls, and briefly outlines these as the categories which are to be examined in detail in the three comprehensive chapters that follow.

Chapter 3, on the essential oils, resins, and related substances which are the fundamental plant products attracting insects that feed on leaves, flowers, fruits, wood, and sap, is a highly effective treatment of 35 pages, with a summarizing discussion and extensive bibliography. Here is brought together the pioneer work of the author himself and of other investigators of this fascinating field, work that effectively substantiates the final conclusion that the so-called botanical sense of insects, which governs their relation to certain taxonomic groups of plants, basically depends on the presence of these substances.

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W. H. WESTON

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The history of auditory theory is an excellent presentation, and should be required reading for all students in the field of hearing. The development of the sequences of ideas, and the relatedness of various theories is very well handled. Likewise, when the author is dealing with factual data in the area of anatomical and neurophysiological data, he is at his best. When, however, the author presents his own theory of hearing, and relates it to present information, the reviewer finds plenty of cause for complaint.

Theories of hearing have usually been much more concerned with the problem of pitch perception than with the problem of loudness perception, partly because it has seemed much easier to explain loudness perception. These theories have in general taken two directions. The place theories explain pitch perception as being due to a different locus of stimulation in the cochlea with different frequencies. Frequency theories, on the other hand, have explained pitch perception as being due to the representation of the frequency of the stimulus in the frequency of neural impulse. In Wever's own theory, which he calls the Volley Theory, he combines these two seemingly opposed theories into one. According to him, the pitch of low tones is mediated only by frequency representation in the neural discharge. Since any single neuron cannot respond at a rapid enough rate by itself, the author resorts to a volley principle, in which it is assumed that various neurons respond at synchronized but staggered rates in such a way as accurately to represent the frequency of stimulation. The pitch of high-frequency tones is determined by a place representation in the cochlea. Intermediate-frequency tones (400 to 5000 cps) have both place and frequency representation.

From the presentation of anatomical and physiological evidence, the reviewer had the impression that the facts favor a straight place theory more than the Volley Theory. There is plenty of evidence that low tones have differential place representation in the cochlea, and in higher neural centers as well. Since place representation does occur, it is difficult to see why resort to a frequency principle is necessary. On the other hand, the facts also show that there is frequency representation up to about 4000 cps in the auditory nerve, but there has never been evidence that the frequency representation holds in higher neural centers. There is no question of the fact that there is some form of frequency representation in the neural discharge, but the question remains: Does this frequency representation have anything to do with pitch perception *per se*? In the reviewer's opinion, the author has not proved his point satisfactorily.

In many cases, there are facts which are difficult for both place and frequency theories. However, the author tends to treat these facts as being in favor of his theory because they are not satisfactorily handled by a place theory. In this connection it should be pointed out that the author usually requires the facts to be explained by a simple, high-resonance kind of place theory, which nobody believes today anyway. The evidence is clear that there is no discrete resonance, in the sense that only one fiber of the basilar membrane is activated for a particular pitch. Modern place theories, however, do not assume such discrete resonance, and the facts are much more easily explained without this assumption.

As an example, Neff's work on partial sectioning of the eighth nerve showed that high tone deafness usually results, and that low tones are rarely disturbed until complete deafness. It is true that this is difficult to explain with a place theory, but it should cause the Volley Theory equal difficulty. Since, according to the Volley Theory, low tones involve neurons from almost the entire cochlea, then *any* loss of neurons should affect sensitivity for low tones. On the other hand, since high tones involve only small specific groups of neurons, sensitivity to them should be affected only when those specific fibers are cut. Yet the author uses these data as evidence for his theory.

In another instance, the author cites the fact that differential pitch sensitivity requires a relatively constant number of cycles per second at low frequencies, but a relatively constant ratio of cycles per second at high frequencies. The integrated difference limen function agrees quite well with the pitch function, and fairly well with data on loss of sensitivity with lesions on different parts of the cochlea. And yet the author uses the fact that a relatively constant number of cycles is required for differential sensitivity at low frequencies as support for his theory, because "it is reasonable to find a differentiation that is constant or nearly so in terms of cyclic change." Why this assumption is reasonable is not explained, and it is difficult to accept when we recall that differential sensitivity in nearly all areas of sensation is a relative matter. Also, the author explains loudness as being represented by the total rate of neural discharge, and yet he does not expect the difference limen to be represented as a constant number of additional units of discharge. This kind of reasoning seems too opportunistic.

In another instance, the author finds it convenient to explain away a fact that cannot fit his assumption of frequency representation. The intensity-pitch relation shows that the pitch of low tones becomes lower with an increase in intensity, and that of high tones becomes higher. This relation, particularly for low frequencies, is very difficult for a theory which requires exact frequency representation. And we find, according to the author, that the change is not really one of pitch, but rather a kind of general confusion. As one who has experimented on the pitch-intensity relations, the reviewer would like to insist that the difference is one of pitch, and not confusion.

In a chapter on tonal interactions, the author finds that place theories have a great deal of trouble explaining beats and difference tones. This difficulty is due only to the straw man of discrete and narrow resonances which the author sets up. Modern place theories have no difficulty with these problems, when distortion in the middle ear is assumed (and such distortion is demonstrated in the cochlear microphonics shown by the author), and when overlapping areas of stimulation on the basilar membrane are allowed. Likewise, in a later chapter on temporal phenomena, in discussing amplitude modulation effects, the author states that as the rate of modulation increases, the ear "gives . . . a whole series of transition phenomena that our mathematics provides no reckoning of." Such a statement is true only if infinitely narrow resonance units are assumed, and again we state that such an assumption for place theories is not necessary, nor is it done. A series of adjacent electric filters can be set up which will give all the transition phenomena which are found in the human ear, and it is quite unnecessary to assume a frequency representation.

In this same chapter, the perception of interrupted tones is discussed, and the author points out that a tone corresponding to the rate of interruption *can* be heard. Such a tone should be heard according to a frequency principle, but when such tones are heard they are very faint. Such faint tones can be easily explained as the products of the non-linear distortion in the middle ear. Also, the sideband components generated with interrupted or amplitude-modulated tones can be distinctly identified with the use of a probe tone to generate beats. These phenomena occur at low frequencies as well as high frequencies, and are far better explained on the assumption of a place analysis than on the assumption of frequency representation.

In conclusion, it is the reviewer's opinion that this would have been an excellent book if the author had had a better theory of hearing to work with. Too many of the facts of hearing have trouble being explained by a frequency principle, and the constant attempt of the author to use such an explanation in the book detracts from its value as a sourcebook of information on the theories of hearing, or for information on the neurophysiology of hearing. If the theoretical arguments were taken out of the book, the remainder would still be an excellent and scholarly review of facts well worth the reading by anyone interested in the general field of hearing.

W. R. Garner

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Documenta Ophthalmologica: *Advances in Ophthalmology. Volume III.*

Edited by F. P. Fischer, A. J. Schaeffer, and Arnold Sorsby. Dr. W. Junk, 'S-Gravenhage. Fl. 36.00. 328 pp. + 3 plates; text ill. 1949.

This volume contains most of the papers which were read at the conference on colour vision held in Cambridge, England, between July 28th and August 2nd, 1947. The contributors, and the titles of their papers, are: The Present Status of the Trichromatic Theory (W. D. Wright); Retinal Structure and Colour Vision (S. Polyak); The Laminar Pattern of the Lateral Geniculate Nucleus Considered in Relation to Colour Vision (W. E. Le Gros Clark); The Analysis of Retinal Elements by the Micro-Electrode Technique (R. Granit); The Photochemistry of Vision (G. Wald); Increment Thresholds and the Mechanisms of Colour Vision (W. S. Stiles); The Polychromatic Theory (H. Hartridge); Colour Vision in the Central Fovea (E. N. Willmer); Colour Discrimination and the Influence of Colour Contrast on Acuity (D. L. MacAdam); Colour Recognition of Very Small Light Sources (J. G. Holmes); Current Views on Colour Blindness (D. B. Judd); Brightness, Visual Acuity and Colour Blindness (S. Hecht); Some Aspects of Anomalous Vision (F. H. G. Pitt); Phenomena Observed in Veiled Colours (S. Kraus); Chromatic Aberration of the Eye (A. Ivanoff); The Two-Quanta Explanation of the Dependence of the Threshold Values on the Visual Angle and the Time of Observation (M. A. Bouman and H. A. van der Velden). This list of contributors is an almost complete roster of the world's foremost color vision scientists.

Although a volume such as this could hardly be expected to be as closely integrated as a textbook, the papers are all concerned with such a specific topic that collectively they present an excellent summary of the status of our knowledge about color vision. Some of the contributors have chosen to present recent experimental data, others have summarized the literature on specific topics, and the remainder are mainly theoretical in nature. The volume is highly technical and is concerned with a highly specific subject but it will be an important addition to the library of the visual scientist.

A. Chapanis

ANIMAL NUTRITION

Enseignements de la Guerre 1939–1945 dans le Domaine de la Nutrition. *Médecine et Biologie, Number 6.*

Edited by E. J. Bigwood. Masson & Cie., Paris; Editions Desoer, Liège. 760 fr. (paper). 470 pp. + 3 charts; text ill. 1947.

This volume contains the papers presented in a symposium on nutrition during the war period, under the presidency of Professor Bigwood. The symposium was international in character, and was participated in by men from Denmark, the United States, France, Holland, Portugal, Switzerland, and Sweden. The subjects presented were: edema due to protein deficiency; hemeralopia due to vitamin A deficiency; the effects of wartime diets on diabetes; gastrointestinal ulcers; dental caries; dermatoses; tuberculosis; and some more general observations on the health of the human population during the war period. Three papers were devoted to animal nutrition during the war. These were primarily devoted to the problem of protein resources in animal production in Great Britain, Denmark, and the Netherlands, respectively. The authors of papers were men of distinction, and the volume forms an important contribution to the history of the food problems of humans and animals, as determined by dearth caused by war in parts of Western Europe.

E. V. McCollum

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NUTRITION OF THE DOG. *Second Edition.*

By Clive M. McCay. Comstock Publishing Company, Ithaca. $3.50. xiv + 337 pp. 1949.

The author is a distinguished nutrition investigator and has had much personal experience with his subject. It is not too much to say that the breeder, owner, or veterinarian will find in this volume the answers to most of his questions about the nutritive requirements of the dog and how to provide them. There are chapters on Men and Their Dogs, Carbohydrates, Proteins and Fat in the Diet of the Dog, Amino Acids and Protein Derivatives, Mineral Requirements, Fat-Soluble Vitamins, Water-Soluble Vitamins, Modern Dog Feeds, The Ingredients of Dog Feeds, Plant Foods, Testing Dog Feeds, Blood and Bone, Practical Feeding and Management of Dogs, Kennels and Equipment, Parasites and Their Control, Questions about Feeds, A Shelf of Books for the Dog Owner, with an Index of Persons and an Index of Subjects.

The book is well documented with references to scientific papers, placed at the end of each chapter. The total number of references is 374. Every statement is based on experimental data. The reviewer believes this to be the best book in its field.

E. V. McCollum

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FEEDING OUR DOGS.

By Leon F. Whitney. D. Van Nostrand Company, New York, Toronto and London. $3.50. vi + 243 pp. 1949.

This is a book of a very different kind from the one just described. Part I includes an Introduction, Feeding Don'ts, The Evolution of the Dog, and Its Natural Food, the Mechanics of Digestion, and The Chemistry of Digestion. Part II discusses Protoplasm and Protein, Carbohydrates, Fats, Bulk, Water, Minerals, and Vitamins in the Dog's Diet; Calories—the Measurement of Heat in Food; and the question Do Foods Cause Skin Troubles? Part III discusses Foods from Vegetables, Fresh Food from Animals, Packing House By-products, Commercial Dog Foods, and Part IV covers the topics How Much Food Does a Dog Require?; Feeding Methods and Costs; Home Mixing Our Dog Foods; Foods for Special Conditions; and Feeding Problems. There is an Appendix on properties of foodstuffs, and this is followed by the Index.

On pp. 12–13 there is a list of dog diets, designated A to Y, of which it is stated that "Each diet has proved successful in maintaining dogs in excellent condition insofar as food is able to do so." In this list, under C, there is a list of six diet formulas said to have been worked out at universities by years of careful testing. No. 1 in this list consists of a mixture of cane sugar, lard, bone ash, casein, butter, and salt mixture. I believe that no dog could long survive on such a diet. The same may be said of some others in the list. Much of Part I is written in a facetious spirit, and is absurd. The book is not documented, and reads like a compilation prepared by one with little knowledge of physiology or biochemistry from semi-popular articles as sources.

E. V. McCollum

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BIOPHYSICS

THE STRUCTURE OF MATTER.

By Francis Owen Rice and Edward Teller. John Wiley & Sons, New York; Chapman & Hall, London. $5.00. xiv + 361 pp.; ill. 1949.

In almost every way this is a very unusual book. The authors undertake to explain quantum mechanics without the use of mathematics, and then to apply these explanations to the theory of the chemical bond, solid state forces, spectroscopy, and nuclear chemistry. Far from being too complex to understand for readers without training in advanced physics, it may actually suffer from the disadvantage of being too easy to understand and thus may make the reader feel that he understands points which in reality he does not. This disadvantage, if it is real, is certainly slight beside the very real advantage of making it possible for workers in the biological fields to have at least some understanding of the structure of molecules and the nature of chemical bonds. Of course, a knowledge of the subject obtained in this way will be superficial, inasmuch as it is seldom possible for the authors to prove the statements made and still to adhere to the plan of keeping mathematics out of the book. Such superficiality can be defended if one balances against it the very considerable amount of formal training which would be required of a reader, if the same material were presented rigorously.

L. J. Mullins

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SPECTROSCOPIC PROPERTIES OF URANIUM COMPOUNDS. *National Nuclear Energy Series, Manhattan Project Technical Section. Division III, Volume 2.*

By G. H. Dieke and A. B. F. Duncan. McGraw-Hill Book Company, New York, Toronto and London. $2.75. xviii + 290 pp. 1949.

This book presents a mass of data on the absorption and fluorescence spectra of a wide variety of uranyl compounds and of a few other uranium compounds. These studies were made on the crystalline solids at different temperatures down to 20° K. The dispersion and resolving power of the instruments used were in general sufficient to resolve the full spectral structure. Included in the presentation is a chapter on the crystallographic structure of rubidium uranyl nitrate, as well as chapters on a variety of techniques and observations incidental to this work. Some of these include observations on the synthesis of particular compounds, effects of isotopic substitution of uranium 235, and the oxygen and nitrogen isotopes and techniques used for growing the large single crystals required in this work. The data for this book were obtained by a group of workers on the Manhattan Project assigned to studies of possible photo-chemical separations of the uranium isotopes. This is an excellent reference work and will be particularly useful to those concerned with solid state investigations.

C. F. Hiskey

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Nuclear Radiation Physics.

By R. E. Lapp and H. L. Andrews. Prentice-Hall, New York. $6.00. xvi + 487 pp.; ill. 1948.

This book is written primarily for persons with little background in physics, and as such should prove to be of use as a textbook in nuclear physics courses designed for the non-physicist. By including numerous practical problems, illustrative examples, and an extensive bibliography, the authors have made the book well suited for use as a textbook. Particularly noteworthy are the definitions of the various fundamental units of radioactivity. As a rule, these definitions are supplemented with illustrative examples of a practical nature which should help to make their meaning clear to the student interested in the practical aspects of nuclear physics.

The material in the first five chapters is essentially background material, including a consideration of waves and particles, atomic structure, and x-rays. Of necessity the treatment of these subjects is brief, but the important basic concepts are covered. Chapters six through eight treat natural radioactivity, isotopes, nuclear structure, and nuclear radiations. Aside from a clear presentation of the factual material, these chapters include concise definitions of those quantities primarily useful to the nuclear physicist, (packing fraction, mass defect, binding energy, etc.). Chapters nine, ten, and eleven are devoted to ionization chamber instruments, Geiger-Muller counters, and radiation measurements, respectively. Included with the presentation of the operating principles of the various radiation detectors is a discussion of the limits of usefulness of each instrument. In the next five chapters various aspects of nuclear reactions are discussed; such topics as artificial radioactivity, particle accelerators, the neutron, nuclear fission, and nuclear chain reactions are covered. Chapter seventeen, on radioactive tracer technique, seems to be a little sketchy, considering the importance of the material covered to the biologist, biochemist, and physician. A more detailed discussion of the methods of assay commonly used would be appreciated. The final chapter on Health Physics should be of general interest to those who are working with radioactive materials. Other items of interest contained in the book are tables of useful data on radio isotopes, a list of rules and procedures concerning radioactivity hazards, and a list of manufacturers of radiation instruments.

F. D. Carlson

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Handbook of Radioactivity and Tracer Methodology. *AF Technical Report 5669. Parts One, Two and Three.*

By William Siri; with contributions by Ellsworth C. Dougherty, Rayburn W. Dunn, James S. Robertson, Cornelius A. Tobias, Patricia R. Weymouth and Maurice C. Fishler. Department of the Air Force, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio. $20.00 for three parts (paper). (1) ii + pp. 1–432; ill.; (2) Pp. 433–582; ill.; (3) Pp. 583–867. 1948.

Isotopic Tracers and Nuclear Radiations *With Applications to Biology and Medicine.*

By William E. Siri; with contributions by Ellsworth C. Dougherty, Cornelius A. Tobias, James S. Robertson, Rayburn W. Dunn and Patricia P. Weymouth. McGraw-Hill Book Company, New York, Toronto, and London. $12.50. xiv + 653 pp.; ill. 1949.

This book, which appeared first in the limited edition under the aegis of the Army Air Forces early in 1948, and standing first above, has now been revised, enlarged, put into general circulation as the second title listed. It makes available a large mass of data on nuclear radiations collated mainly with the interests of biophysicists in mind. The rather formidable result of this collation, interspersed with what is in general a very adequate description of nuclear processes, is an extended tome which, to quote the jacket announcement, is intended to bridge "the gap between those books intended solely for the nuclear physicist and those which merely describe the results of research in which radioactive isotopes and nuclear radiations were used."

The book is divided into three sections. The first two deal with isotopes, nuclear processes, methods, and instrumentation, and comprise the bulk of the work. The third section, covering only some 38 pages out of a total of 500 in the text, is given over to a discussion of tracer methodology. This rather one-sided organization is the result of the decision to concentrate on the physical rather than biological or chemical aspects. However, if one were to take the quotation given above at face value, one would wonder why, if those volumes already available "merely describe" results of research with tracers and nuclear radiations, the authors have been content to refer to these same volumes for more extended treatment of tracer methodology.

The biochemist or physiologist who is interested in the every-day problems of tracer methodology at the working level will not receive much help from this book. However, while most biochemists will not be particularly interested in the great bulk of the data presented, there are many chapters which clinical physiologists and medical biophysicists will find very useful. It seems to the writer, therefore, that the volume would gain immeasurably by deletion of the third section with its associated bibliography and tables. Much of the material on methods and instrumentation has become easily accessible in relatively moderately priced books since this volume was projected. Hence, by deleting or abridging those chapters containing this material, such as chapters 1, 10–15 inclusive, and 19, to cite just a few, this book could be tightened up and brought into a size and price range within reach of all interested. The writer feels that many valuable data have been presented here (and nowhere else) which should be generally available, and that these data should not be included in a matrix of already familiar material which must be purchased along with them.

The book is printed on a glossy stock paper, and legibility is good. The activity of printer's gremlins appears to be low, but a few errors have crept into the text, such as the one in which "atomic number" is stated in the text when "atomic mass" is meant (p. 170).

MARTIN D. KAMEN

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BIOLOGICAL REACTIONS CAUSED BY ELECTRIC CURRENTS AND BY X-RAYS. *A Theoretical Study of the Phenomena of Excitation in the Nerve by Different Electric Currents and of the Biological Reactions Caused by X-rays, Both Based Upon a Common Principle.*

By J. Th. Van Der Werff. Elsevier Publishing Company, New York, Amsterdam, London, and Brussels. $5.00. xii + 203 pp.; ill. 1948.

On theoretical grounds there would seem little reason to believe that there is any similarity between the physical processes involved in nervous excitation and those involved in the responses of living systems to x-irradiation. One would rather say that excitation and conduction in nerve reflect the high degree of organization of the cell surface, while radiation effects result from the very random series of chemical species produced in the bulk of the cell. The author of this book has, however, undertaken to develop a mathematical analysis of both these processes on the basis that both effects result from an alteration of the "dynamical equilibrium between assimilation and dissimilation" (i.e., anabolic and catabolic processes). Such a postulated effect is brought about by changes in ion concentrations in both cases. Without considering in detail the data which the author has presented in correlating his theory with the known facts of neurophysiology, one can say that such a theory suffers from many of the difficulties of other mathematical theories, in that it tells the reader essentially nothing about the physical processes involved. Such analyses are inherently no better than purely empirical formulae.

The treatment of the effects of x-rays on living systems is, in some respects, more satisfactory, while in others most unsatisfactory. The introduction of Poisson functions to describe the events occurring seems more justifiable than in the case of excitation. The data used to verify results which are calculated are not those which have been independently obtained (such as mutation rate changes) by several investigators. The explanation of radiation effects appears too simple in view of the known complexity of the purely chemical effects of ionizing radiations. The book is difficult to read because, presumably, of the author's or translator's unfamiliarity with English. It has, further, a strong flavor of vitalism which may disquiet the reader.

L. J. MULLINS

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BIOCHEMISTRY

OUTLINES OF PHYSICAL CHEMISTRY.

By Farrington Daniels. John Wiley & Sons, New York; Chapman & Hall, London. $5.00. viii + 713 pp.; ill. 1948.

This is a new edition of the former Getman & Daniels textbook. While the revision is not very extensive, there is little reason for revision at all, as this has for many years been an admirable book. It can be highly recommended to students of biology who need a more basic knowledge of physical chemistry than that which can be obtained from the many books claiming to present "physical chemistry for students of biology and medicine."

L. J. MULLINS

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INTRODUCTION TO RADIOCHEMISTRY.

By Gerhart Friedlander and Joseph W. Kennedy. John Wiley & Sons, New York; Chapman & Hall, London. $5.00. xiv + 412 pp.; ill. 1949.

Written as a textbook for chemists, this book has a great deal of material which is essential for biologists working with radioactive isotopes. As the authors have noted in their Preface, the title Radiochemistry needs some explanation. It is not the effects of radiation on chemical substances, but rather the chemistry and physics of radioactive substances. Those readers familiar with *A Manual of Radioactivity*, by Hevesy and Paneth, will find the subject matter of the two books comparable. The advances of this subject since the last edition (1938) of the latter book, have made an up-to-date treatment of the subject imperative.

A historical introduction to radioactivity is followed by a theoretical discussion of atomic nuclei and their reactions. Later chapters deal with sources of bombarding particles, radioactive decay processes and the statistical considerations involved, techniques for the measurement of radiation, and three chapters on the chemistry of radioactive species. The treatment throughout does not assume previous knowledge of nuclear physics and is satisfying both from a theoretical and a practical standpoint.

L. J. Mullins

Principles of Organic Chemistry.

By John Leo Abernethy. W. B. Saunders Company, Philadelphia and London. $4.00. viii + 317 pp.; ill. 1949.

This is a concise and lucid introduction to organic chemistry. The author has eliminated much of the material that "tends to make organic textbooks encyclopedic sources of information, discouraging to the beginning student." Of attractive format, the book could fit into an overcoat pocket. In addition to a well organized systematic survey of typical organic compounds, there are brief sketches of theories of electronic structure, bond strain, resonance, orientation influences of substituent groups, and organic oxidations and reductions. Brevity is a great virtue, but here it has been carried a little too far for optimal usefulness in introduction to theory. There are only occasional hints of such amenities as the historical development of the subject or variation in degree of certainty, and no specific citations of source materials or supplementary reading. There are a few errors. Fats are discussed in 9 pages, proteins in 11, and carbohydrates in 20, including optical activity and the proof of the glucose structure. There are student exercises at the end of each chapter, and a good index. The book, in general, reads easily and should be of real value for introductory orientation among the carbon skeletons.

Evelyn Howard

The Chemistry of High Polymers.

By C. E. H. Bawn. Interscience Publishers, New York. $4.50. x + 249 pp.; ill. 1948.

This book fulfills a real need in the field of physical polymer chemistry. It will be extremely useful to polymer chemists interested in the kinetics of polymerization. This does not mean to imply that other topics in physical polymer chemistry, such as The Structure, Stereochemistry and Crystallinity of High Polymers; The Structure and Physical Properties of High Polymers; and The Size and Shape of Macromolecules are neglected, for these topics are also treated in a clear and reasonable fashion.

There has been a tendency for books written in the polymer field to be extremely specific and only to cover limited topics in great detail. This book, without oversimplification, has treated a wide variety of general topics. Thus, it is extremely valuable to the polymer chemist or graduate student in polymer chemistry who desires a fundamental knowledge in the field. Unfortunately, the book has omitted a segment of polymer chemistry concerned with the application of organic reaction mechanisms to polymer problems. Likewise, the application of synthetic organic chemistry to polymer problems has been omitted. Irrespective of these omissions, the book is excellent and a valuable contribution to the polymer literature.

C. G. Overberger

Fortschritte der Biochemie, 1938–1947.

By Felix Haurowitz. S. Karger, Basel and New York. sFr. 40.00. viii + 364 pp. 1948.

The problem of compressing the results of nine years of biochemical research into a volume about one half the size of the *Annual Review of Biochemistry* is certainly formidable, and it is quite difficult to decide how well this has been done. It is relatively easy to point out deficiencies with respect to completeness of coverage for those fields with which one is especially familiar. However, the wide range of the fields covered, and the integration of the various chapters in the book rather makes one wonder whether we shouldn't have such a book in English. The book should be very useful in seminar courses, and as a general reference for non-specialists.

L. J. Mullins

Outline of the Amino Acids and Proteins. *Second Edition.*

Edited by Melville Sahyun. Reinhold Publishing Corporation, New York. $5.00. 286 pp.; ill. 1948.

This introduction to the protagonists in the biological drama, the proteins (and amino acids), was designed as an elementary survey of a field in which several comprehensive works have appeared in recent years. Separate chapters on certain aspects of the chemistry and metabolism of the proteins and amino acids have been contributed by C. L. A. Schmidt, H. B. Bull, H. E. Carter and I. R. Hooper, D. M. Greenberg, M. Heidelberger, A. J. Quick, W. M. Cahill and A. H. Smith, M. Womack and C. F. Kade, and M. Sahyun.

Since the appearance of the first edition in 1944 (see Q.R.B. 20: 297. 1945) the editor has added a timely chapter on the utilization and assay of amino acids by microorganisms. Each chapter has a fairly extensive bibliography.

EVELYN HOWARD

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FATTY ACIDS AND THEIR DERIVATIVES.

By A. W. Ralston. John Wiley & Sons, New York; Chapman & Hall, London. $10.00. x + 986 pp.; ill. 1948.

The author is an outstanding contributor to the chemistry and technology of the substances about which he writes. About 100 patents have been granted to him for his discoveries in this field. He is Assistant Director of Research for Armour and Co., of Chicago. His qualifications for authorship in the field of his specialty are thus unsurpassed. The first part of the book is devoted to the fatty acids, their occurrence in nature, their synthesis, and their chemical and physical properties. The second part deals with the synthesis and properties of derivatives of fatty acids, and includes esters, amines, nitriles, alcohols, ethers, mercaptans, sulfides, sulfonates, anhydrides, acid chlorides, aldehydes, ketones, hydrocarbons, soaps, etc. As a reference book this is the best of its kind. There is a 42-page index of topics, but no author index. More than 5000 references to technical literature are included in the bibliographies which follow each of the 12 chapters.

E. V. MCCOLLUM

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NATURAL PRODUCTS RELATED TO PHENANTHRENE.

Third Edition of the Monograph Previously Entitled Chemistry of Natural Products Related to Phenanthrene.

By Louis F. Fieser and Mary Fieser. Reinhold Publishing Corporation, New York. $10.00. xii + 704 pp. 1949.

This excellent and comprehensive survey of a major field of organic chemistry first appeared in 1936 as *Chemistry of Natural Products Related to Phenanthrene*, by L. F. Fieser (see Q. R. B. 11: 362. 1936). The authors have aimed to present "reasonably complete topical discussions of a selection of the main points of interest in the chemistry of the phenanthrene derivatives, and to survey more briefly the biochemistry and pharmacology of the compounds. Since the publication of the first and second editions of this book in 1936 and 1937, vast strides have been made in the development of the chemistry of naturally occurring phenanthrene derivatives, particularly the steroids. By 1937 most of the important physiologically active steroid hormones and vitamins had been isolated and their structures established, but very little was known of their stereochemical configurations. Extensive studies of the stereochemistry of the steroids have culminated only in recent years and months in the complete solution of all the major problems concerned. This, therefore, is a particularly appropriate time to present a revision in which we hope we have accurately interpreted a highly confused and voluminous literature in the light of present day stereochemical evidence that seems secure. . . . the present edition represents a complete overhauling of the original book." Some of the earlier chapters and sections have been omitted: e.g., the chemistry of phenanthrene, the carcinogenic hydrocarbons, and the triterpenoid sapogenins. Even so, the book is twice as long as before. Chapter headings are: Quinones; Morphine and Related Alkaloids; Resin Acids; Sterols and Bile Acids; Sex Hormones; Adrenal Cortical Hormones; Steroid Metabolism; Cardiac Active Principles; Steroid Saponins; Steroid and Terpenoid Alkaloids; and a final chapter, by Richard B. Turner, on The Stereochemistry of the Steroids.

EVELYN HOWARD

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AN INTRODUCTION TO THE CHEMISTRY OF CARBOHYDRATES.

By John Honeyman. The Clarendon Press, Oxford; Geoffrey Cumberlege, Oxford University Press, London. $4.00. viii + 143 pp. 1948.

As the horizons of research expand ever wider, it becomes increasingly difficult for the individual investigator to remain conversant with all of the advances within his own discipline. These difficulties are multiplied immeasurably as he ventures farther away from his immediate interest. Yet with each advance within his own field he rubs elbows with neighboring branches of science and must frequently incorporate some aspects of these into his work. Thus the biologist must familiarize himself more than ever before with the fields of chemistry and physics.

One solution to his dilemma lies in the publication of textbooks which are concise and basic, yet sufficiently advanced and detailed that they may serve both in an introductory and an advanced capacity. The fulfillment of such a requirement is not so paradoxical as it might appear at first examination. Honeyman's small (143 pages) volume is a prime example.

As the author has stated in his Preface, his aim ". . . has been to provide, in compact form, an up-to-date account of the chemistry of a selected number of carbohydrates. No previous knowledge of the field is assumed, but the reader requires to be familiar with the elements of aliphatic and aromatic chemistry. The monosaccharides are considered in detail in order to provide an adequate basis for studying further the more complex carbohydrates. In addition to the crystalline di-, tri-, and tetrasaccharides, a few of the simpler polysaccharides of colloidal dimensions are discussed." The configurations and constitution of the sugars are especially clearly presented. The intricacies of ring structure, *d* and *l* forms, and α and β isomers are unraveled expertly.

Biologists whose work carries them into the field of carbohydrate chemistry can hardly do better than to consult this volume. It will serve equally well as a refresher or an introductory textbook.

V. G. Dethier

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Newer Synthetic Analgesics. *Annals of The New York Academy of Sciences. Volume 51, Article 1.*

By M. L. Tainter, H. J. Anslinger, R. C. Batterman, R. N. Bieter, S. Bogolub, K. K. Chen, N. B. Eddy, L. Glassman, B. B. Hershenson, S. A. Hirsh, R. W. Houde, H. Isbell, E. H. Jenney, J. S. LaDue, L. C. Miller, E. E. Nelson, C. C. Pfeiffer, L. H. Rasmussen, E. A. Rovenstine, M. H. Seevers, L. F. Small, R. R. Sonnenschein, and F. F. Yonkman. The New York Academy of Sciences, New York. $2.75 (paper). Pp. 1–174; ill. 1948.

This monograph presents in a well-documented survey the latest information concerning the use of the newer synthetic analgesics, which are: demerol from the piperidine series, methadone from the diphenyl butanone series, and metapon, the newest of the opiate derivatives. The chemistry, pharmacology, analgesic efficiency, drug-addicting properties, and drug complications of each of the three are presented by the outstanding authorities in this field.

As Dr. Batterman concludes that side reactions are much more severe and frequent in the ambulatory than in the hospitalized patient, physicians who use these agents should be prepared to treat promptly the occasional vascular collapse, cerebral edema, bronchial spasm, or respiratory depression in the best environment.

Evidence is presented that many of these agents are better for some individuals than morphine from the standpoint of analgesic efficiency and lack of side effects. Nevertheless, they should be accepted as alternates for morphine and not entirely as substitutes for this most valuable drug. The results concerning many drugs in this series, such as Nisentil, are not yet definite enough to indicate their superiority over demerol. Their use in obstetrics should be carefully regulated, especially for premature deliveries, since in combination with general anesthesia they can, like morphine, perpetrate and accentuate fetal apnea neonatorum. Nevertheless, demerol, at least in obstetrics as in surgery and therapeutics, has already proved itself a reliable analgesic. The other new analgesics in the field of obstetrics are more unpredictable in a potential dangerous depression.

Scientists studying these agents cannot find a better collection of papers on this subject than this.

Robert A. Hingson

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MICROBIOLOGY

Practical Bacteriology, Hematology, and Parasitology. *Tenth Edition.*

By E. R. Stitt, Paul W. Clough, Sara E. Branham, and Contributors. The Blakiston Company, Philadelphia and Toronto. $10.00. xiv + 991 pp. + 7 plates; text ill. 1948.

In the eleven years which have elapsed since the ninth edition of this well-known textbook appeared, many advances have been made in the fields which the book embraces. Extensive revisions have consequently been made, amounting to rewriting the sections on Bacteriology and Parasitology. As in earlier editions, the aim of the authors has been to correlate laboratory and clinical evidence. They have included all the available types of laboratory procedures, including newer methods in the various fields. In the section on Hematology, for example, procedures discussed include new work on human blood groups, the Rh factor and its relation to transfusion reactions and erythroblastosis fetalis, preservation of blood for transfusions, and substitutes for blood. The authors have continued to bear in mind the needs of the man in tropical or remote regions, who does not have access to well-equipped libraries or laboratories. This edition, like earlier ones, is completely indexed.

Max Krauss

⁂

The Chemical Activities of Bacteria.

By Ernest F. Gale. Academic Press, New York; University Tutorial Press, London. $2.25. vi + 199 pp.; ill. 1948.

This little volume is an authoritative condensation of present-day knowledge of bacterial metabolism. Many synthetic and analytic transformations performed by bacteria are briefly reviewed, and their significance in bacterial activities, including pathogenicity, are discussed. Eleven chapters cover such subjects as the nature of bacteria, enzymes, growth, the nitrogen cycle, fermentation, and chemotherapy. The twelfth and final chapter, Some Practical Details, is a sort of appendage to the theoretical considerations, and is inferior to the rest of the book, in the opinion of the reviewer. However, with the exception of the last chapter, the book may be highly recommended. It provides an able, concise, yet elementary presentation of a confusing and difficult subject. It is well suited to introduce the subject to students, or to review it for workers in the fields of bacteriology, cytology, and biochemistry.

HARRIETTE D. VERA

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ANTIBIOTICS DERIVED FROM BACILLUS POLYMYXA. *Annals of The New York Academy of Sciences. Volume 51, Article 5.*

By P. H. Long, C. M. Alverson, M. J. Baker, P. H. Bell, R. G. Benedict, E. A. Bliss, J. F. Bone, R. Broschard, G. Brownlee, M. S. Bryer, S. R M. Bushby, B. N. Carle, J. R. Catch, C. A. Chandler, A. C. Dornbush, G. M. Eisenberg, J. P. English, C. E. Fellows, R. C. Gore, K. S. Howard, E. R. Jackson, T. S. G. Jones, G. Krupka, S. Kushner, C. L. Larson, P. Little, E. M. Petersen, J. N. Porter, E. T. Reese, M. M. Rogers, E. B. Schoenbach, R. G. Shepherd, E. I. Short, P. G. Stansly, F. H. Stodola, Y. SubbaRow, A. E. Verder, H. J. White, S. Wilkinson, R. Winterbottom, and J. S. Zellat. The New York Academy of Sciences, New York. $2.25 (paper). Pp. 853–1000; ill. 1949.

AUREOMYCIN—A NEW ANTIBIOTIC. *Annals of The New York Academy of Sciences, Volume 51, Article 2.*

By B. M. Duggar, L. Anigstein, J. Beninson, E. A. Bliss, A. E. Braley, R. L. Brickhouse, M. S. Bryer, C. A. Chandler, M. C. Clark, H. S. Collins, R. Cosgrove, H. R. Cox, R. W. Cunningham, A. C. Dornbush, H. F. Dowling, M. Finland, B. K. Harned, C. H. Hine, L. M. Hill, E. H. Lennette, M. H. Lepper, P. A. Little, M. A. Logan, P. H. Long, W. J. McCauley, G. Meiklejohn, T. F. Paine, Jr., E. J. Pelcak, C. W. Price, A. Prigot, W. A. Randall, M. Sanders, E. B. Schoenbach, E. Stokey, Y. SubbaRow, L. K. Sweet, H. M. Thelen, R. E. Vessey, H. Welch, D. M. Whitney, S. C. Wong, L. T. Wright and N. N. Yuda. The New York Academy of Sciences, New York. $2.50 (paper). Pp. 175–342 + 3 plates; text ill. 1948.

HEALTH AND DISEASE

EVALUATION OF CHEMOTHERAPEUTIC AGENTS. *Symposium Held at the New York Academy of Medicine March 25 and 26, 1948. Number Two.*

Edited by Colin M. MacLeod. Columbia University Press, New York. $4.00. xii + 205 pp.; ill. 1949.

In the Introduction, the editor points out that this Symposium (Symposium Number Two of the Section on Microbiology) dealing with the evaluation of chemotherapeutic agents was "designed to be broad in scope—an attempt to evaluate in a general way certain of the many factors involved in the success or failure of treatment. It has been felt that such a method of presentation is of more value than a division of attention based upon the use of specific compounds in the therapy of particular diseases."

The scope is illustrated fairly by an outline of the topics discussed, which include treatments of the significance of drug concentration in the blood, blood levels and renal clearance in relation to the chemotherapeutic activity of penicillin and certain arsenicals, the significance of protein-binding by various agents, microbial resistance, defense mechanisms of the host, the nature and location of lesions, antibiotic therapy of localized infections, chemoprophylaxis of certain infections, the evaluation of antimalarial drugs, the chemotherapy of rickettsial diseases and of viral infections, and current attempts to define experimental approaches to cancer chemotherapy.

The various subjects are handled in separate chapters by authorities in the several fields. Such authoritative authorship in this instance has served to create a rather unusually interesting and valuable symposium volume. The book may be said to deal with a multitude of facets peculiar to a vigorously growing field. The biochemical basis of chemotherapeutic activity is not stressed here. The work has fulfilled its purpose in providing a number of critical essays on the evaluation of the agents.

LESLIE HELLERMAN

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FLIGHT FROM REALITY.

By Norman Taylor. Duell, Sloan and Pearce, New York. $3.50. 237 pp. 1949.

This interesting book deals with various narcotic and so-called habit-forming drugs. The history of usage connected with each one is presented in chronological order and in a highly readable manner, and the many anecdotes are entertaining.

Although the author has at times used the scientific approach, the book itself is not, and was not intended to be, a scientific reference book. All in all, a good piece of work has been done in shedding light on how, where, and why, man found these substances—chiefly from plant life—in order to "break the bonds that chain him to reality."

ROBERT V. SELIGER

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ANAESTHETICS AND THE PATIENT. *Sigma Introduction to Science 15.*

By Gordon Ostlere. Sigma Books, London. 7s. 6d. 166 pp.; ill. 1949.

This monograph is directed, according to the author, to an imaginary audience of medical students and collateral scientists, as an introductory compendium presenting the background and present status of anesthesia. The first four chapters, on history, practical anesthesia, how anesthetics work, and the stages of anesthesia, are basically authoritative and undoubtedly provide useful knowledge for chemists, biologists, any physicists who have contingent liaison with the field of medicine. Likewise, the chapters on the anesthetic drugs, premedication, the development of anesthetic apparatus, are presented in an attractive manner.

The last section of the book, dealing with technic, however, and discussing the applications of anesthetics to the various branches of obstetrics and surgery, does not conform to the opinions of many practicing anesthesiologists today. The decreasing popularity of local and spinal anesthesia throughout Great Britain is contrary to the increasing application of these technics in America. The chapter on anesthesia in midwifery indicates that the author has seen very little satisfactory obstetrical anesthesia. The author's inaccuracy in reporting that caudal analgesia in obstetrics is administered both by the midwife and the mother herself is regrettable. The following sentence illustrates the unwarranted levity in style used through too much of this chapter: "A 'Caesar' actually requires little in the way of anaesthetic to begin with, for, although the abdomen is opened to reach the baby, the mother's abdominal muscles are stretched by her pregnancy to such an extent that they offer little resistance to the hand of the surgeon." During the last four years, as reported to the Congress of Obstetrics in London last year, 77,000 caesarean sections were performed in thirteen major British Hospitals with a maternal mortality of 77. Many of these deaths were related or due to anesthesia. In some sections of England and America maternal mortality from this operation is reported as from one to four per cent, and subsequent infant mortality approaches 12 per cent. There is no operation which requires a more careful assessment of a safe, specifically adapted anesthetic for both mother and baby than caesarean section.

The chapter on curare is basically accurate and is written in an interesting manner. The last three chapters, describing the complications, modern anesthesia, and anesthetics and the patient, conclude a readable elementary description of this phase of the specialty.

ROBERT A. HINGSON

PARAVERTEBRAL BLOCK *in Diagnosis, Prognosis, and Therapy. Minor Sympathetic Surgery.*

By Felix Mandl; translated by Gertrude Kallner. With a foreword by Max Thorek. Grune & Stratton, New York. $6.50. xviii + 330 pp.; ill. 1947.

The author of this book, Felix Mandl, is affiliated with the Hadassah University Hospital in Jerusalem. The first division of his subject consists of three chapters: The Anatomy of Paravertebral Injections; The Technic of Paravertebral Injections; and The Object and Theory of Effect of Paravertebral Block. The second major division has five chapters, dealing with Differential Diagnostic Significance of Paravertebral Block in Abdominal Diseases; Paravertebral Block as a Test Method; The Therapeutic Application of Paravertebral Block; Paravertebral Block in the Treatment of Various Disorders of the Extremities; and Paravertebral Block in the Therapy of Various Diseases and Ill-Defined Conditions. The book has few illustrations or drawings and relies mainly on summaries of cases and case histories for its demonstrations.

The author starts by defining the object of paravertebral injection, namely, to produce anesthesia in the neighborhood of the ganglionated sympathetic cord, the sympathetic ganglia, or rami communicantes of the segments to be eliminated in each case. It is also a very brief review of the anatomy of the vertebral cord and sympathetic system. Mandl next discusses six methods or technics of paravertebral block, all using novocain ($\frac{1}{2}$ or $\frac{1}{4}$ per cent) or novocain-alcohol, with a consideration of their complications and toxic effects.

In Section Two, it is shown that paravertebral block, with proper selection of cases and proper technic, is a valuable aid in the differential diagnosis of cases of abdominal diseases, especially in distinguishing gall bladder pain from renal pain, gastric pain, or pancreatic pain by injection into different thoracic and lumbar segments on the right or left sides. The use of paravertebral blocks as a test method preceding a sympathectomy has been found very useful in predicting the outcome of the operation, although a negative result does not mean the patient would receive no benefit from the operation. In many cases it was found that novocain alone, or novocain-alcohol injection, lessened the need for an operation. The therapeutic application of paravertebral block in relieving the pain of gall bladder or kidney disease was found to be very efficient and often aided or caused the expulsion of calculi. It is efficacious because it abolishes pain rapidly, and also abolishes spasm of the abdominal organs, making a definite change in the tonicity of the organ's musculature by acting through the afferent fibers running through the sympathetic nerves. Considerable space is devoted to discussing the application of paravertebral block to relieve angina pectoris and other "cardiac pain." Paravertebral block is considered the safest and yet the most successful method for the relief of angina pectoris. It has been used successfully to relieve paroxysmal and sinus tachycardia in selected cases. In other cases of pleural pain, pulmonary complications, and asthma, paravertebral block has been used with moderate success. In combination with sacral or transsacral alcohol block for inoperable cases of cancer of pelvic organs it has yielded good relief. It was poor in essential hypertension.

Other conditions in which paravertebral block has proved of much value are: peripheral vascular disorders resulting from injury; arterial spasm; wounds of arteries; arterial hematoma, or false aneurysm;

A-V fistula; traumatic arteritis; traumatic venous thrombosis; after division of peripheral nerves; organic vascular diseases; local effects of cold; and such painful disorders of the extremities as phantom pain after amputation, causalgia, and reflex dystrophy. Sympathectomy was preferred in thromboangiitis obliterans, and very few results were obtained from paravertebral block in cases of Raynoud's disease.

An appendix includes a discussion of the use of paravertebral block in the last war and in rehabilitation surgery. The author believes the complications of vascular and nerve injury will be greatly prevented by his technics and will be of major importance in the future wars.

This is an intelligently written work by a person who has evidently spent many years in studying his subject and is an expert with this technic. He gives evidence of much search of literature on this subject, especially for the period 1916–1933. Although this is commendable, it has tended to make the book confusing in parts because so many theories and refutations are presented. Paravertebral block has been shown to be useful in many cases, but some of these uses can now be replaced with simpler technics, such as continuous caudal, segmental peridural, or spinal blocks.

ROBERT A. HINGSON

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PRÉCIS DE BACTÉRIOLOGIE MÉDICALE.

By Pierre Gastinel. Masson et Cie., Paris. 2800 fr. xvi + 1040 pp. + 1 plate; text ill. 1949.

This new textbook of medical bacteriology has been written by a Professor of Bacteriology of the Faculty of Medicine of Paris, to replace the older work of Philibert and Gastinel. The main divisions of the work are comprised of an introduction to general bacteriology and immunology, general bacteriological technique and examination of pathological specimens, and descriptions of individual microbes pathogenic to man, including bacteria, viruses, and protozoa. All organisms likely to be encountered in a laboratory of medical bacteriology are fully characterized, and the immunology, serology, and chemotherapy of infections, as well as other relevant material are recorded.

The classification of Prévot is compared with that of the 1948 edition of Bergey's *Manual of Determinative Bacteriology*. The nomenclature used in the text generally follows that of Prévot, but synonyms are also given. The book is thorough, comprehensive, and detailed, presenting both theoretical and practical aspects of the subject. American workers will undoubtedly find it interesting and useful as a reference. Within the text, however, citations from the original literature are rare; there is almost no bibliography. There are occasional typographical errors. The table of contents follows the index at the end of the book.

HARRIETTE D. VERA

AN INTRODUCTION TO MEDICAL MYCOLOGY. *Third Edition.*

By George M. Lewis and Mary E. Hopper. The Year Book Publishers, Chicago. $8.50. xvi + 1 plate; text ill. 1948.

This third edition continues to serve excellently the stated purpose of the authors "to serve as a primer—it does not pretend to include all the many controversial details and involved technical aspects of the subject." Since the first edition, however, this book has been used to advantage by beginners and advanced students alike. The first-hand experience of the authors with the materials presented and their ability to present concisely this material has allowed the book to become a standard textbook in medical mycology.

The original plan of the book has been maintained with two sections. The first deals with the clinical, theoretical, and experimental aspects of fungus infections; and the second, with laboratory methods. Advances in medical mycology since the second edition (1943) have been added without materially increasing the length of the book. The original illustrations are without fault, and the additional figures also are excellent.

NORMAN F. CONANT

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VIRUS DISEASES OF MAN. *Second Edition.*

By C. E. van Rooyen and A. J. Rhodes. Thomas Nelson & Sons, New York. $22.50. xiv + 1202 pp.; ill. 1948.

This second edition is a substantially improved and extended, but basically unaltered, revision of a book that fulfills excellently the purpose stated in its preface: "to provide a volume of reference for both the laboratory worker and clinician interested in the field of human and animal virus infections." In the opinion of the reviewer, this book remains the best treatment of the subject available in English. It is indeed remarkable that two workers have mastered and organized so critically such a wealth of factual information and bibliographic material.

The form of presentation is a succession of statements of published observations, which reminds the reader of another excellent book, Topley and Wilson's classic *Principles of Bacteriology and Immunology*. This makes the book more useful for reference purposes than if the subject matter had been treated in a more discursive way. The first section, on methodology, is adequate but disproportionately short and scanty in the treatment of the theoretical considerations underlying the methods described. The main part, sections 2 to 12, contains a detailed discussion of all virus diseases of man whose etiology is well established. Rickettsial diseases are not discussed, although the psittacosis-lymphogranuloma venereum group of diseases, a borderline group, is included.

Altogether, this volume, following the classical approach of medical virology, appears to be the best that the pathologist can do in attempting to do justice to this field. It will be very useful also to those workers who are now attempting to approach the virus problem as a primarily biological problem.

S. E. Luria

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Atlas of Cardiovascular Diseases. *Correlation of Clinical Electrocardiography and Cardiac Roentgenology with Clinical History and Autopsy Findings.*

By Irving J. Treiger. The C. V. Mosby Company, St. Louis. $10.00. 180 pp.; ill. 1947.

Treiger has correlated the classical uncomplicated clinical history and physical signs, roentgenologic findings, electrocardiographic changes, and gross pathology in the more important varieties of cardiovascular conditions. The book begins with a sound presentation of the normal heart and then takes up rheumatic heart disease, arteriosclerotic heart disease, hypertensive heart disease, syphilitic heart disease, and congenital anomalies of the heart and large blood vessels in an orderly, museum-like fashion. The generally satisfactory roentgenograms, electrocardiographic tracings, and photographs (some in color) are accompanied by a minimum of text, so that individual cases may be studied quickly.

Unfortunately the electrocardiograms include only the four old standard leads. There is but passing mention of multiple precordial leads and no consideration of the valuable unipolar limb leads. In addition, selection and quality of a number of the pathological specimens could easily be improved.

Despite these criticisms, the atlas is well integrated and can be thoroughly recommended as a brief review and reference book in this important field.

E. Converse Peirce, 2nd

◆

The Peripheral Circulation in Health and Disease. *A Study in Clinical Science.*

By Robert L. Richards; With a Foreword by J. R. Learmonth. E. & S. Livingstone, Edinburgh. $6.00. xii + 153 pp.; ill. 1946.

As a result of the segregation of similar cases by the British Medical Research Council, Dr. Richards has had an unparalleled opportunity to study large groups of peripheral vascular diseases which are ordinarily infrequently observed. His small book is a beautifully written and scholarly account of his studies of these diseases, primarily by means of skin temperature measurements. Fully aware of the limitations of his method, the author has reviewed the related literature very thoroughly and has skilfully integrated it with his own observations.

The book includes a concise and critical account of the anatomy and physiology of the peripheral vasomotor system, a clear discussion of methods of study with particular reference to skin temperature measurements, an exposition of spontaneous and imposed vasomotor activity, and the results of studies in four major groups of peripheral vascular disorders: occlusive vascular disease, the Raynaud phenomenon, peripheral nerve injuries, and the immersion foot syndrome. There is much material not readily available in other works on the subject. Each chapter is fully annotated. Those who are seriously interested in studies of peripheral circulation will find this book a considerable addition to their libraries.

E. Converse Peirce, 2nd

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Your Skin and Its Care.

By Howard T. Behrman and Oscar L. Levin. Emerson Books, New York. $2.50. 255 pp.; ill. 1948.

The authors, who are skin specialists, present a program of skin hygiene which will help to "beautify the skin, to avoid skin disorders, or—should they already exist—to correct them." Underlying causes of skin diseases are discussed at length, symptoms are described, and treatments indicated. The relations between skin and general systemic conditions are set forth, and the authors touch upon recent psychosomatic developments in dermatology. The uses of cosmetics in skin care and their dangers receive appropriate attention. This book is a popular household reference manual on the proper care of the skin, so often neglected. It is practical, and will be easily understood by the average reader. A glossary, index, and eleven illustrations are included.

Joseph C. Franklin

◆

Medical Aspects of Growing Old.

By A. T. Todd. A William Wood Book. The Williams & Wilkins Company, Baltimore. $3.50. viii + 164 pp.; ill. 1946.

This little book is principally a handbook on rules for healthful living. Clearly and simply written, it should be of definite value to any layman who wants to enjoy a vigorous old age. The first three chapters are devoted to a consideration of the real and supposed changes associated with ageing. Here Todd states his thesis that the wearing out of the body is "not . . . by the attrition of so much work, but rather, as in the case of badly kept machinery, from neglect and ignorance." The remaining 16 chapters provide detailed instructions on how to care for the machinery of the body. The problems of diet and digestion are dealt with at length, as might be expected. Cardiovascular troubles, genito-urinary disorders, and care of the nose, skin, hair, and feet are taken up, and there are also chapters on sleep, exercise, and the requisites of a satisfactory retirement. Throughout, the author is completely specific, and his advice is often refreshing for its simplicity and directness. The sufferer from insomnia, for example, is advised to get up and try staying awake.

No one who writes on health is entirely free from personal prejudices, and Todd is no exception. Milk he regards as virtually a toxic substance in the adult diet; and grey hair he classifies among the "results of incorrect living." But these are minor flaws in a book distinguished for its good sense. Above all the author stresses the simple and natural means of fostering and preserving health. The book may be especially recommended to those who have exposed themselves too much to the misinformation purveyed in advertisements and newspaper columns. There are two appendices dealing with the caloric and vitamin content of common foods, and also a surprisingly good index.

FLORENCE MOOG

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MODERN TRENDS IN PUBLIC HEALTH.

Edited by Arthur Massey. Paul B. Hoeber, Medical Book Department of Harper & Brothers, New York. $12.50. xii + 581 pp.; ill. 1949.

This monumental work of 23 monographs by a like number of British experts covers most of the broad field of public health, and is presented as a summary of the development of British health services and activities during the recent war and the early phases of social readjustment which have followed. Such topics as Nutrition and Public Health, Public Health Nursing, School Health Service, Occupational Health, and Health Education are discussed in relation to the total British public health situation by leading authorities in the several disciplines. In many instances, the historical development of the particular phase of public health under consideration has been presented, as well as some indication of those trends most likely in the future. Since the monographs are complete within themselves (each with summary and bibliography), they have been arranged by alphabetic order of the author's name.

The monographs reveal patterns of social development in public health which will undoubtedly be studied and discussed with equal interest by those either advocating or opposing any major change in the status of public health and medicine in the United States. Although the work has been prepared by British Public Health experts, drawing upon their British experience, there is sufficient material here of general interest and application to the entire field, that it can be profitably used for classroom or reference work in public health training and activities in any part of the English-speaking world. A complete index is appended.

B. AUBREY SCHNEIDER

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PUBLIC HEALTH IN THE WORLD TODAY.

Edited by James Stevens Simmons; assistant editor, Irene M. Kinsey; with a foreword by James Bryant Conant. Harvard University Press, Cambridge; Geoffrey Cumberlege, Oxford University Press, London. $5.00. xviii + 332 pp. + 5 plates; text ill. 1949.

This is a collection of twenty-four papers which were presented at a series of Public Health Forums held at Harvard University in 1947–48. The four sections of the book are: The Profession of Public Health; Public Health in the United States Today; Public Health Programs and Problems Abroad; and Public Health in a New Era. The development and present-day concepts of public health are set forth in a vigorous and forceful manner. The status of federal health and medical care services, nutrition, occupational hygiene, and child health is surveyed. Problems of transportation, especially aviation, and of international organization for the promotion of public health services are discussed. The advent of the atomic era, with its new implications for public health, is not forgotten. The result is a timely and significant publication. It should be read carefully and thoroughly by those who are concerned with, or profess any interest in education, public health, medicine, or world affairs. It is thought-provoking and enlightening.

HARRIETTE D. VERA

PSYCHOLOGY AND ANIMAL BEHAVIOR

HISTORICAL INTRODUCTION TO MODERN PSYCHOLOGY. *Revised Edition.*

By Gardner Murphy. Harcourt, Brace and Company, New York. $4.50. xiv + 466 pp.; ill. 1949.

This is the second edition of Murphy's popular textbook. The first half of the book, made up of two parts on the early history of psychology, has been changed only a little; the second half has been extensively revised. The latter contains two parts: one, consisting of six chapters, under the heading of Contemporary Psychological Systems; the other, also with six chapters, on Some Representative Research Areas.

Murphy's history is more eclectic than Boring's *History of Experimental Psychology*—the only other good textbook in the field. In his attempt at comprehensiveness, however, Murphy has had to sacrifice the kind of detail that characterizes Boring's book. As one might expect, the sections on psychological systems and contemporary research areas, particularly the latter, reflect the author's own perspectives. Although it would be virtually impossible, of course, to escape some bias, it is unfortunate that the author did not present a more balanced synopsis of current trends in research. Despite its shortcomings, this book, like its predecessors, is a useful addition to the psychologist's library.

A. CHAPANIS

DYNAMIC PSYCHOLOGY. *The Century Psychology Series.*

By Percival M. Symonds. Appleton-Century-Crofts, New York. $3.75. x + 413 pp. 1949.

This textbook of psychology constitutes an abridgment of a previous book, *The Dynamics of Human Adjustment.* The book leans heavily on psychoanalytic interpretations while claiming to eliminate those quotations less acceptable to the consciousness of most persons and hence which seem least convincing. It also eliminates the dynamics of abnormal states and its unfamiliar vocabulary. There are chapters on the ordinary varieties of human tendencies and of mental mechanisms, and a final chapter on normality. There occurs twice (p. 2) an unfortunate misuse of a term, a misuse not excusable in a textbook: "It conceives of man as an organism which is responsive to the world about and who is capable of *affecting* efficient adaptation to the environment through the operation of his mental processes." "Although they function on more simple and rudimentary levels than man, they also *affect* a working relationship with their environment." [Italics added.]

WENDELL MUNCIE

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THE CHILD IS RIGHT. *A Challenge to Parents and Other Adults.*

By James Hemming and Josephine Balls. Longmans, Green and Company, London, New York, and Toronto. 6s. xiv + 176 pp. + 7 plates. 1947.

This is a determinedly cheerful little book gaily addressed to parents. The authors are reported to "have worked for many years among children of all ages," but the exact nature of this work is not explained. Whatever it was, it made possible a phenomenal accumulation of anecdotes to illustrate homey truths about how to understand children. These "truths" are good natured, common-sense ideas which can hardly be over-stressed, but their presentation here seems to fall flat. This may be due to the British authors' use of English idioms which strike an American reader as forced or inappropriate, or it may be that neither author has a real gift for the humorous style which can by some magic take a serious topic and make it palatable and effective at the same time.

HELEN ARTHUR

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GROW UP—AND LIVE. *Pelican Books 149.*

By Eustace Chesser. Penguin Books, Harmondsworth, Middlesex. 1s. 6d. (paper). 295 pp. 1949.

Chesser has written an informal, chatty book directed toward the adolescent reader. He covers a tremendous area—beginning with descriptions of the various body systems, going through a section of early childhood problems, and concluding with several chapters on attaining maturity. At first glance it might seem that he has taken in too much, but when it is recalled that to the adolescent the world is just such a panorama of past, present, and future questions, it seems to be a peculiarly appropriate approach for the audience he has in mind. Throughout, he steers a middle course between the over-elaborate explanation and the useless generality or discreet euphemism. Altogether, this seems like quite a good book to give an intelligent teenager whose family has not been able to talk freely with him.

HELEN ARTHUR

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HOW PERSONALITIES GROW.

By Helen Shacter. McKnight and McKnight, Bloomington, Illinois. $3.00. 256 pp.; ill. 1949.

Helen Shacter has written a very readable little book. She quietly and interestingly introduces the reader to the concept of personality, and then effortlessly leads into some of the complicated facets of personality development, the different social needs that influence a person's reactions, and at length some of the various defense mechanisms that operate along with efforts to satisfy these social needs. The last two chapters are concerned with suggestions for improving one's personality in the light of increasing self-knowledge.

How Personalities Grow is remarkable for its clear, cool style. It can be read rapidly. Frequent pleasant pictures make the going even easier. Behind this surface, however, is a core of genuine feeling and information conveyed to the reader without tension or passion. This volume would seem especially suitable for women —from highschool or college girls on in years—who are often deeply concerned with their personalities and what to do about them.

HELEN ARTHUR

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PSYCHOLOGY OF PERSONAL ADJUSTMENT. *Students' Introduction to Mental Hygiene. Second Edition.*

By Fred McKinney. John Wiley & Sons, New York; Chapman & Hall, London. $6.00. xii + 752 pp. + 12 plates; text ill. 1949.

This is a beginning textbook in psychology, but it is certainly appropriate reading for any person, particularly any college student, who is interested in the problems of adjustment. It is specifically directed toward the adjustment of the college student, beginning with the most concrete sorts of problems, such as efficient study methods, and the development of personal efficiency in college. From this specific and concrete beginning, the most general and abstract problems of conflict and frustration are gradually introduced. The final sections of the book deal with general social adjustment and the implications of psychology for a healthier society. The book is very readable throughout, profusely illustrated with case material and some very effective photographic illustrations. This edition, in contrast to the first, presents more conceptualization of the problems of personality, but it is not a coherent presentation of a scientific theory of personality. Some readers may object to the book on these grounds, but if so they quarrel with the author's objectives. For what he intended, the book is extremely well done.

ALFRED L. BALDWIN

ESSENTIALS OF PSYCHOLOGICAL TESTING.

By Lee J. Cronbach. Harper & Brothers, New York. $4.50. xiv + 475 pp.; ill. 1949.

The field of psychological testing has become, according to Cronbach, so complicated that a survey of psychological tests is no longer a feasible undertaking. Instead, the emphasis should be upon the intelligent choice of tests. In this volume the author has attempted to provide the student with criteria for making intelligent choices of tests which will suit the particular needs of the situation.

The book seems well designed to achieve the author's purpose. Among other discussions there is an excellent one on reliability and validity, a good section describing the importance of the subject's perception of the test situation, and very competent concise reviews of material on a number of specific tests. In discussing tests of ability the contributions of factor analysis are well described. The final section describes various kinds of measurements of personality characteristics, including behavioral observations. The discussion of projective tests seems somewhat weaker than the rest of the volume.

ALFRED L. BALDWIN

INTRODUCTION TO THE SZONDI TEST. *Theory and Practice.*

By Susan Deri; with a foreword by Lipot Szondi. Grune & Stratton, New York. $5.00. xiv + 354 pp.; ill. 1949.

This is the first discussion in English of a projective personality test devised by Dr. Lipot Szondi, a Hungarian psychiatrist. In the test itself the subject chooses from each of six series of photographic portraits those he likes most and dislikes most. These pictures include homosexuals, sadistic murderers, epileptics, hysterics, catatonics, paranoids, manics, and depressives. By charting the subject's preferences for these various photographs, on a number of occasions, a series of test profiles is obtained. This information permits, according to the proponents of the test, a detailed personality description and diagnosis.

In this book the rationale for this interpretation is presented. Corresponding to the eight types of people in the series of photographs are personality characteristics, which are given a full discussion. The book contains very little empirical evidence which would permit the reader to make an independent judgment about the validity of the test interpretations, but it does present the rationale in such clear, logical fashion that the reader comes away from the book with an open-minded attitude about the possibilities of such a test. Even if the test is invalid, it introduces some extremely interesting psychological concepts that may well be important contributions to psychological thinking.

ALFRED L. BALDWIN

SOME NOTES ON THE PSYCHOLOGY OF PIERRE JANET.

By Elton Mayo. Harvard University Press, Cambridge. $2.50. x + 132 pp. 1948.

Shortly before Mayo and Janet were to commence collaborative work applying the latter's particular psychological views to the study of social and industrial problems, Janet died. This small volume (dedicated to Janet) summarizes the French psychologist's conceptual scheme for clinical study, his equilibrium hypothesis of behavior, and his brilliant delineation of hysteric and obsessional states. On these subjects the exposition is clear and concise. The author's attitude that Janet's theories and work should be appreciated for their contemporary usefulness, rather than for their historical importance in medical and psychological science will be shared by few professional readers. Moreover, the author's unqualified agreement with Janet's general biological bias in the etiology of mental illness and, in particular, with his view that hysteria is a consequence of organic and constitutional degeneracy, is hardly tenable today.

Although the author is concerned to bring the value of Janet's work to the thinking of those dealing broadly with "the difficult social, personal, and administrative problems of our time," he has failed to develop Janet's contribution beyond the level of individual and clinical psychology to its application in interpersonal relationships, except for such generalizations as this:

> The three simple claims of the Janet psychology that I have here outlined are of extraordinary importance to all students of society. The first two—the complexity of the attentive act and the interrelation of action and reflection—he should study under the guidance of a competent psychologist in preparation for his work. This he must do in order that he shall be able instantly to detect the third group of symptoms—constraint and the emergence of obsessive thinking—when such symptoms appear in any social or industrial situation he is studying. For the appearance of such symptoms will warn him that there is some irksome constraint or feeling of insecurity imposed upon the individual or the group studied by the general conditions of the surrounding.

However true such statements may prove to be they fall short, in the reviewer's opinion, of being revelatory or immediately helpful to those to whom the author has directed his book.

As an addendum to his notes on Janet's work, Mayo has included Janet's lecture on Frightened People, a lecture dealing with the need of medical patients for reassurance and urging attending physicians to recognize the importance of psycho-social counseling as a necessary aspect of physical treatment.

Joseph C. Franklin

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Varieties of Delinquent Youth: *An Introduction to Constitutional Psychiatry.*

By William H. Sheldon with the collaboration of Emil M. Hartl and Eugene McDermott. Harper & Brothers, New York. $8.00. xviii + 899 pp.; ill. 1949.

Sheldonism has become something to be reckoned with in these days when panaceas and utopias are sought for in the magic of numbers. Around the Director of the Constitution Laboratory at the College of Physicians and Surgeons of Columbia University there has collected a cult as mandarin-like and as cabalistic as any of those (especially the psychoanalytic) against which he rages wrathfully in a style that reads like the miscegenous mating of Bernard Shaw with Philip Wylie. Latterly he has been taken to the bosom by certain literary luminaries (*habitat Californiensis*): among science-fictioneers he is the acknowledged darling; and for the outraged sensibilities of the anti-Freudians he is the leading manufacturer of precious balm. As he goes forth in print every few years to do battle against the forces of stupidity and evil, he wears the token of the eugenicists on his helmet, whence it flutters in the wind of his going like the squirrel tail from the motorcycle of the young psychopath who just tore past my study window.

In this, the third volume of the Human Constitution Series—and the weightiest by bulk—Sheldon has used delinquency as the vehicle for his diatribes. Two hundred youths, sometime residents of the Hayden Goodwill Inn, a Boston rehabilitation home for boys, provide the raw data for this study. Sheldon presents them in a wearying procession, single file, replete with the by-now-famous Somatotype Performance Test, i.e., triple-view photograph, standard somatotype description embellished with characteristic adjectives and highly subjective paragraphs relating to Temperament, Delinquency, Origins and Family, Mental History, Medical Running Record, Summary, and Comment. Introducing in this volume, for the first time, a scale for the measurement and description of the psychiatric variables as well as a new Index of Delinquency (or Disappointingness), Sheldon now attempts to round out the so-called "biologically oriented psychology" which he hopes will rescue the study of man from the fiendish grasp of the Freudians and set it upon the highroad toward a biological humanics.

The work presented here is open to the same criticisms that have been made against previous work published by Sheldon and his colleagues. Both methodology and statistical treatment betray the author's own Dionysian temper, and he seems not to have taken too seriously the objections raised in scientific quarters against his high-handed way of treating experimental data in the past. While, in this volume, he has gone to commendable lengths to validate his scale for the quantification of psychiatric variables, the ID (Index of Delinquency) appears contrived. Finally, the entire study reveals again the typical Sheldonian scientific sins of limitations of sampling and possible contamination through methodological subjectivity and bias.

In all this welter of data, amidst all the charts, tables, figures, schemes, and photographs with which this giant of a book is filled, the conclusions of the research are quite lost. Perhaps, though, it were better to say they are hidden and obscured by the semantic fog these constitution researchers have raised in their attempt to explain and quantify their work. Diligent search, however, discloses that the "criminals" studied are "pronouncedly ectopenic mesomorphs with about average endomorphy," are of moderately short stature, are psychiatrically Dionysian "with a mild sustaining paranoia," are of average primary *g* (gynandrophrenia) but of a low secondary *g*, and of "almost average primary *t* (aesthetic pleasingness) but of lower secondary *t*," excel in general strength and athletic ability but are of "only average hand strength," and possess a mean IQ "at about the level sometimes called normal subaverage." We learn, too, that their maternal parentage is recognizably "burgeoned," and that they and their sons are, as a whole, cerebropenic; also, that the parents of delinquents are quite as delinquent as the delinquents studied, themselves. The relationship between the burgeoned state and cancer and that between hebephrenia and asthenia give Sheldon an opportunity for some interesting speculations as to biological delinquency, and he takes advantage of it with enthusiasm.

Reading Sheldon, I am always tempted to ask, What's all the shouting about? After all, it was Freud who said, "Anatomy is Destiny"—thus paraphrasing Napoleon—and no psychologist worthy of his degree would question that the morphology and physiology of the body are dynamically interrelated with the functioning organism. I cannot but suspect the company Sheldon keeps and the sources of his information. His special peeve is the psychoanalyst, and upon him he pours a verbal venom that should make even Monsignor Sheen jealous. As a psychoanalyst myself I must object strongly to the sneering implications of Sheldon's characterizations of myself and my colleagues. We do, indeed, have our lunatic fringe; but I rather believe it consists of people who have misread and misinterpreted Freud and his followers exactly and to the same extent as Sheldon has. No psychoanalyst of my acquaintance, at least, would deny the worth of morphological research nor fail to recognize and respect its adjuvant function in the study of man and his behavior. But—if I may speak for the bulk of my colleagues—we do not think that Sheldon's methods or results yet entitle him to speak with the voice of authority and prophecy.

All of this is not to say that Sheldon should not be read. He should; for there is a hard core of scientific truth beneath the exuberant posturings, and the hypotheses upon which the research is founded are certain eventually to assume an important place in the ongoing search for more knowledge about ourselves. Moreover, Sheldon should also be read for the sheer fun of it. In this book, especially Chapter Six is guaranteed to entertain. Here Sheldon, taking his cue from the materials of his research, really lets himself go on his most cherished prejudices—Freudianism, Mr. 7–7–7 (better known as Mr. G or just plain JC), and Roosevelt. While to some of us it may seem strange to find the distinguished proponent of a biological humanics harboring the biases of ordinary mortals and concerned like the veriest college sophomore with what is best described as the apparently permanent effects of a religious hangover, none of us can afford to miss the opportunity to sit at the feet of a modern Jeremiah clothed in cap and gown.

(By the way, Dr. Sheldon, this reviewer is a psychoanalyst: somatotype about 3–3½–4. Primary g $\pm$, secondary $g + 1$. Primary t 4, secondary t 2. Temperament cerebrotonic, ψ probably 5–2–3.)

ROBERT LINDNER

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THE YEARBOOK OF PSYCHOANALYSIS. *Volume 4. 1948. Edited by Sandor Lorand. International Universities Press, New York.* $7.50. 356 pp. 1949.

In the fourth volume of the *Yearbook of Psychoanalysis* the editors have again collected a series of absorbing and provocative papers in the psychoanalytic field. There are twenty-two papers altogether. The first is devoted to an obituary of A. A. Brill, one of the leaders in the psychoanalytic movement in this country, who died in 1948. The next three papers have historical interest in relation to the psychoanalytic movement—one being an actual report from the minutes of the Vienna Psychoanalytic Society, and two concerned with Josef Popper-Lynkeus, a thinker and poet of Vienna who had considerable influence on Freud.

The majority of the papers, contributed by such well-known psychoanalysts as Ernest Jones, Kate Friedlander, and Bernhard Berliner, have to do with specific contributions to psychoanalytic theory. They are all written for the edification and stimulation of those who are already well grounded in basic psychoanalytic concepts, and are extremely challenging. They represent the best of the psychoanalytic writing through the year.

Eight papers in the book are devoted to current psychoanalytic research projects. Five of these have to do with the psychoanalysis of literary material. These are interesting. One, by Felix Deutsch, is an examination of The Respiratory Neurosis of Charles Kingsley. It is a fascinating and learned, detailed examination of *The Water Babies* and *Anton Locke's Dream*, from which the author proves how Kingsley's psychosomatic illnesses directed his literary endeavors. Skinner does a similar kind of psychoanalytic exploration of Lewis Carroll's *Adventures in Wonderland*. It is an interesting case report on the author as seen through his work and some biographical data. In a sense these scientific dissections of well-loved masterpieces detract considerably from one's enjoyment of these classics themselves, but they do contribute rather dramatically illustrated clinical material for a psychoanalytic presentation.

There is no doubt that this *Yearbook*, now in its fourth volume, is an important addition to every psychoanalyst's library. It presents a carefully culled and representative group of the most important papers of the year.

HELEN ARTHUR

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ENCYCLOPEDIA OF CRIMINOLOGY. *Edited by Vernon C. Branham and Samuel B. Kutash. Philosophical Library, New York.* $12.00. xl + 527 pp. 1949.

Under the very best of circumstances, no encyclopedia can be reviewed adequately. The very nature of such a multipedal beast precludes its being treated according to the critical standards usually applied toward other publications. It coheres only because it is thinly united by a topical thread and a meticulous conformance to the punctate demands made upon it by the alphabet. Finally, it labors mightily for completion, catholicity, and authority, but is foredoomed at best to produce only a struggle and a confusion between its covers as it comes closer and closer to realizing such intentions.

The best that can be said about the particular encyclopedia under discussion is that, where the form of publication does not defeat them, Branham and Kutash have performed creditably an onerous task. Criminology is a bastard discipline, a chronic borrower from every possible science and field of study. Perhaps more ambitious editors would have ranged more widely in their search for material and so have demonstrated this further than Branham and Kutash have done; but then the bulk of the product might have frightened away prospective readers. As it stands, there is enough here to demonstrate the tremendous scope and direction of what has always been a fascinating, if little rewarding, adventure of the inquisitive intellect. The subject itself emerges—as it indeed is—an embryonic discipline painfully groping toward a minimum requirement of objectivity on its long way toward sciencehood. Beneath its perhaps too spacious semantic blanket, it has had to pair off and seek to unite strange bedfellows. The outsider who, all unwary, plunges into the midst of its present chaos must, alas, be most impressed by the monstrous couplings he observes, and the queer offspring that to his unaccustomed eye appear to defy Mendelian predictability. All of this, from *Abandonment* to *Usury* and beyond, is well illustrated in the pages of this volume.

As a citizen cognizant of his responsibility to remain informed, the biologist will naturally be interested in this work on a subject so important to the national welfare. As a scientist, he will deplore certain individual pieces for their subjective and undeservedly conclusive tone. As a general reader, he will regret the poor quality of the binding, the unsuitable paper-stock, the completely useless index, and the outrageous price he is asked to pay for a book of only a little more than five hundred pages.

Robert Lindner

HUMAN BIOLOGY

Growing Superior Children. *Revised Edition.*
By I. Newton Kugelmass. D. Appleton-Century Company, New York and London. $5.00. xvi + 590 pp. + 8 plates; text ill. 1946.

Growth and Development of the Young Child. *Fourth Edition.*
By Winifred Rand, Mary E. Sweeny, and E. Lee Vincent. W. B. Saunders Company, Philadelphia and London. $3.00. viii + 481 pp.; ill. 1947.

As indicated by the titles, the approaches of these two volumes differ somewhat. Kugelmass is more concerned with telling people, particularly parents, how to deal with children in order most effectively to promote physical, mental, and emotional growth. Rand, Sweeny, and Vincent are more inclined to describe the growth process and to account for differences. Kugelmass is more inclined to lay down the law, to say "this is so" and to give, for example, very specific and detailed instructions for punishment, sex education, work, play, sleep, exercise, etc. Rand, Sweeny, and Vincent prefer to give evidence of research in these areas. Unquestionably more scholarly in their approach, the latter authors cite 417 references in their bibliography. Kugelmass has no bibliography at all, restricting himself to a glossary. Laymen, however, will probably prefer the treatment by Kugelmass. In the reviewer's experience, most parents are inclined to ask for specific instructions about their children, rather than scientific explanations of behavior and development, or results of research.

The areas covered by the two books are quite similar. Rand, Sweeny, and Vincent begin with current concepts of growth and development. They point out that rapidity is not necessarily desirable, that children may be different yet normal, and that readiness (maturity) is prerequisite to learning. The discussion of home and family as the background of growth is well handled and covers the whole gamut of psychological and sociological forces from birth control to juvenile delinquency. Characteristic of the authors' approach is their statement regarding compensation: "The human body has a tremendous power of compensation in the physical realm. It learns to adjust itself sometimes to almost unbelievably difficult handicaps, and it would seem as if this principle were true in regard to other aspects of life as well. One would not deliberately set up economic, physical or social handicaps for any child, but if they do occur one must not consider them necessarily overwhelming, dooming the child to what the condition seems to indicate. There may be inherent in the very challenge of difficult situations compensations worthy of consideration and the liabilities may indeed become assets."

The ensuing discussions deal with preconceptional preparations, including such matters as preparation of the siblings; physical equipment (in great detail) for growth and development; care and feeding of the growing child, including frequent citations from research and descriptions of individual cases; intellectual growth; and social and emotional growth. The 63 illustrations are very good in general. The intent of the authors that the book be used as a textbook is revealed by the itemization of topics for class discussion, as well as references at the end of each chapter. *Growth and Development of the Young Child* is a fourth edition, and the major alterations are in the fields in which most new knowledge has been attained in recent years: those dealing with intellectual, social, and emotional growth.

Growing Superior Children is also a revised edition, and in this instance the greatest amount of change is reported to be in the area of nutrition. The title of the opening chapter is Perfecting the Newborn Prenatally. The next chapter deals with Evaluating the Newly Born Baby. Throughout the book, the emphasis is on "promoting, perfecting, cultivating and adjusting." A quotation from Chapter 20, Personality in the Making, may be revealing. "Instinct is the most deep-seated mechanism of the central nervous system. It operates through the bodily organs as equipped by Nature, whereas intelligence devises new tools for self-preservation. Instincts, however, are molded into the very flow of life, which intellect can neither comprehend nor modify. Whatever the developmental status of the individual, the instinctive drives persist unto his end. The major instincts are self-preservation, sex, and sociality, and upon the adjustment of these, much of the personality depends." There are nine plates and 29 drawings and diagrams, most of which are very good. Probably more illustrations would have been helpful in both books. The dust jacket on Kugelmass' book is most attractive.

The reviewer may seem to have favored unduly the book by Rand, Sweeny, and Vincent. In all fairness, the difference in purpose of the two books should be kept in mind. There is undoubtedly a place for such books as *Growing Superior Children.* If taken cum grano salis and followed by a healthy dose of something like *Growth and Development of the Young Child,* it might serve a very useful purpose.

ARTHUR LICHTENSTEIN

* * *

TEMPERATURE AND HUMAN LIFE.

By C.-E. A. Winslow and L. P. Herrington. Princeton University Press, Princeton. $3.50. xiv + 272 pp. + 5 plates; text ill. 1949.

Most investigators concerned with problems of heat exchange between the human body and its environment are familiar with the series of papers on the subject which issued from the John B. Pierce Laboratory of Hygiene over the years 1935–1940. These described methods of partitional calorimetry and derived principles from their use which enabled a satisfactory mathematical expression to be given to such problems of heat exchange. They undoubtedly deserve a place in history as critical developments in the field of thermal physiology. Most workers with whom the reviewer has talked, however, share with him, at least in private conversation, a certain impatience with the complexity of the presentation adopted in these papers. The first three chapters of this volume summarize much of this material, and do so in a way which is much simpler than that used in the original papers. The claims of the publisher that "the discussion may be followed by anyone with a background of elementary science" are quite true; but readers will need a fairly firm determination, for the style is still more pedagogic than stimulating. It is the hope of the reviewer that such determination will indeed be shown by an important number of "architects, heating and ventilating engineers, designers of clothing, public health officials, doctors," etc., since the orientation to be obtained from this book is essential if they are to appreciate the modern approach to problems of man's welfare in the face of environmental stress. For reasons which are set out in one of the later papers (A. P. Gagge, *Amer. J. Physiol.,* 131: 93–103. 1940), variations in atmospheric humidity are given a subordinate place in the authors' considerations, but this detracts somewhat from the direct application of their work to hot humid conditions, where vapor pressure must enter largely into practical considerations. The fourth chapter extends the concepts developed in the earlier ones to the design and use of clothing, and the next two chapters do the same for air conditioning. Those faced with tropical problems could wish that as much emphasis had been placed upon hot as upon cold conditions, but the weighting is a natural one. The attention given to the design of tropical headgear is perhaps excessive, since the heat absorbed from solar radiation is conveyed from the skin before it can penetrate the skull and adds only fractionally to the total heat load of the body. The last chapter discusses the relationships between climate, season, and health. To the reviewer this smacks too much of certain popular generalizations, and stakes too much upon the assumption that the coexistence of a life process or state with certain geographical conditions is proof of a causal relationship. Its inclusion tends to weaken the scientific merit of the book, and to cloud the objective scientific interest which inspired the Pierce Laboratory investigations. Nevertheless, the book as a whole is well worth study, though with diligence and independent judgment.

DOUGLAS H. K. LEE

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MAN IN THE PRIMITIVE WORLD. *An Introduction to Anthropology. McGraw-Hill Series in Sociology and Anthropology.*

By E. Adamson Hoebel. McGraw-Hill Book Company, New York, Toronto and London. $5.00. xii + 543 pp.; ill. 1949.

This new textbook of anthropology is about midway between the short, factual, practical book for the undergraduate and the lengthy, sophisticated, theoretical treatise that might be admirable or not, depending on the quality of its theories, but is in any case somewhat beyond the needs of the undergraduate. It is an intelligent, competent treatise, best in its chapters on social relations like marriage, property, law, and government. It also gives attention to fields like housing and art, often neglected in textbooks. The latter chapters profit particularly from the excellent illustrations.

ERWIN H. ACKERKNECHT

* * *

GENERAL ANTHROPOLOGY.

By Harry Holbert Turney-High. Thomas Y. Crowell Company, New York. $4.00. xx + 581 pp.; ill. 1949.

Among the many recent attempts to bring out a useful textbook in anthropology for undergraduates, this seems to be the most practical we have seen so far. While it might lack the more or less brilliant formulations and subjectivities of other enterprises, the author still adheres to the almost forgotten, but well-tried rule "that the undergraduate should be grounded in descriptive facts before being launched into theory." Thus he describes competently the basic data on physical anthropology, archeology, ethnography, and ethnology. Numerous well chosen illustrations enhance the pedagogic value of this text, which is also praiseworthy for its manageable proportions.

ERWIN H. ACKERNECHT

◆

THE THEORY OF HUMAN CULTURE.

By James Feibleman. Duell, Sloan and Pearce, New York. $5.00. xiv + 361 pp. 1946.

This is a metaphysical speculation on the nature of human culture, and is based on the hypothesis that culture is the result of the response made by members of a social group to a hierarchy of three fundamental human drives—feeding, breeding, and inquiry. In this, at least, Feibleman avoids the single motive explanation so popular with some of his contemporaries, particularly those who are disciples of Freud (sex), Marx (economic), or Nietsche (will-to-power). Also he is, shall we say, more conservative than Ratzenhofer, who postulates five basic motives.

The author divides his subject in three parts. The first part, on the Elements of Culture, deals with The Human Individual, The Theory of Common Sense, The Theory of the Ethos, The Organization of Culture, The New Ethnology, Types of Culture, and The Movement of Culture. Part II deals with some examples of culture, such as the Maya, Pueblo, and Baiga, as representatives of early cultures, and with those of the Chinese and English, as examples of advanced cultures. In Part III of the book some consideration is given to the Treatment of Culture, its advancement both from a social and individual point of view, and to the possible question of a science of culture.

With the exception of Part II of the book, this reviewer found it rather heavy going, and suggests that those readers who may be interested in the book try this sample before plunging in:

"The psychological order whereby psychic events follow one another in time is a compromise between the logical order of being or possibility and the historical order of existence or actuality. The psychological order endeavors to apprehend the logical order in the historical, to bring to earth by means of feeling, reasoning and acting the logical possibilities of ontological values which have not yet been made available to experience. Students of philosophy, psychology and biology are fond of pointing to the faculty of reasoning and the cognition of universals as the distinguishing characteristic or ability marking off the human being from the higher animals. Feeling they condemn as a faculty shared by human beings with the higher animals, but this is an error made in consequence of dividing reasoning too sharply from feeling. There is another error involved, and this consists in assuming that while reasoning cognizes universals, feeling is only affected by the concrete, on the further assumption that not only are reasoning and feeding divided but also universals and values. Through the cognition of universals, the feelings are led to apprehend abstract values" (p. 22).

DAVID B. TYLER

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THE COMMUNITY OF ERAI (WETAR). (*Texts and Notes*). *Studies in Indonesian Culture, II. Verhandelingen Der Koninklijke Nederlandsche Akademie Van Wetenschappen, Afd. Letterkunde. Nieuwe Reeks Deel L, Number 2.*

By J. P. B. De Josselin De Jong. N. V. Noord-Holandsche Uitgevers Maatschappij, Amsterdam. f. 7.50 (paper). iv + 152 pp. + 1 plate; text ill. 1947.

Erai is a hamlet on Wetar, an island north of Timur. J. P. B. D. deJong spent 18 days in Erai. Most of his book consists of 25 texts, mostly myths, collected during this time, together with their translations, grammar, and vocabulary. In a 32-page Introduction the author reconstructs from the hints given in the texts the nature of the family system, ritual, warfare, and material culture of Erai, combining with it what little observational material he had collected. This is a useful but not very impressive monograph.

ERWIN H. ACKERKNECHT

◆

THE BANTU TRIBES OF SOUTH AFRICA: *Reproductions of Photographic Studies. Volume III, Section II, The Nguni: Section II, The Mpondo and Mpondomise. With an Introductory Article on the Mpondo and Mpondomise, and Descriptive Notes on the Plates.*

By A. M. Duggan-Cronin; introductory article and notes by Monica Wilson. Deighton, Bell & Company, Cambridge, England; Alexander McGregor Memorial Museum, Kimberley. 25s. (paper). 19 pp. + 40 plates. 1949.

This is another volume of the photographic anthology of the South African Bantus. As in previous volumes: 1) the pictures are posed too often for this reviewer's taste; 2) an excellent introduction is provided by a first-rate anthropologist who possesses an intimate knowledge of the tribe, in this case Mrs. Monica Hunter Wilson.

The 330,000 Mpondo and the less numerous Mpondomise show all the familiar Bantu traits: family kraals, the cattle complex, ancestor worship, etc. An interesting variation is that, unlike the aggressive Zulu and Swazi, they organized their defensive regiments not on an age group but on a territorial basis. Modern conditions, keeping 50 per cent of the able bodied men away in the mines, soil erosion, etc., have produced serious disruptions of tribal life.

ERWIN H. ACKERKNECHT

THE NEGRO IN THE UNITED STATES.

By E. Franklin Frazier. The Macmillan Company, New York. $6.00. xxxii + 767 pp.; ill. 1949.

The well-known sociologist to whom we owe already so many excellent detailed studies of the Negro problem gives here a synthesis of his own and the total body of existing research on it. He describes the development of the Negro community and its institutions, and the emergence of the Negro as a racial minority. A first part of the volume is devoted to the social and economic status of the Negro under slavery. The second part deals with "emancipation," following the disenfranchisement of the Negro and the restoration of "white supremacy" in the South. A third part contains an extensive demographic and sociological analysis of all types of present-day Negro communities, their classes, the Negro family, churches, fraternal organizations, and business. Education on all levels, the Negro press, intelligentsia, and social movements are reviewed in part four. The fifth part discusses problems of adjustment like health, family disorganization, crime, and race prejudice. Frazier emphasizes the tremendous change in the status of the Negro during the last thirty years, brought about through urbanization and the great migrations of the two World Wars.

One is struck by the comprehensiveness and scientific value of the study under consideration as well as by the extreme wealth of detailed studies of high quality upon which it could be based. They too might be not merely a reflection, but a real factor in the change of the last 30 years. The only major omission is an analysis of the experiences in the armed forces in World Wars I and II. Sometimes parallel figures for the white population (as in the case of the occupational "pyramids" on pp. 293, 295, 297) would have been desirable. As a whole this is a most valuable book.

ERWIN H. ACKERKNECHT

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THE AMERICAN WOMAN IN MODERN MARRIAGE.

By Sonya Ruth Das. Philosophical Library, New York. $3.75. iv + 185 pp. 1948.

According to the author, the emancipation of woman has advanced farther in the United States than anywhere else, thanks to voluntary motherhood, economic independence, intellectual progress, political freedom, and the feminist movement; and hence American women have acquired a "new individuality." Marriage has become a functional and dynamic relationship, and the family has become a democratic organization. This has brought about a few problems like the necessity of a new code of feminine ethics, and the adjustment of the conflicting interests of modern woman as individual, mother, and wife.

The little book is the adaptation of a French Ph.D. thesis of 1934, and as dull as it should be. It gives a few useful data, but less than one would expect in view of the detailed work done by others in the field. The author is a feminist, and thus feels, in spite of reporting our appalling divorce rate (31 per cent in 1945), that everything over here is just fine.

ERWIN H. ACKERKNECHT

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VOLUNTARY PARENTHOOD.

By John Rock and David Loth. Random House, New York. $3.00. viii + 308 pp. 1949.

According to the publishers' blurb, this is a "self-help book in the sense that it is meant to help the reader plan his or her own family." Basically it is a sound piece of work, as one would expect from the distinguished authors. As a guide for layman, however, it seems open to criticism on several counts:

1. It is written in a rather verbose style and contains much material which seems not to be relevant to the subject. Included are a number of "case histories" about Harry and Harriet, or the B——'s, etc. This is an effective educational device if used sparingly, but it will irritate some readers if used to excess.
2. The technical detail offered in certain chapters, especially those on the causes and treatment of infertility, is far too great for the layman's need and understanding. On the other hand, one wonders whether it would not have been possible to list the jellies, creams, and suppositories tested and approved by the American Medical Association, especially since other contraceptive procedures are described with complete directions for use.
3. There are no bibliographic references whatsoever, neither as documentation for specific statements (including many quoted directly), nor as suggestions for further reading.
4. The Catholic point of view is represented fairly in the words of the Rev. Francis J. Connell of the Catholic University of America. However, the implications of this point of view are only hinted at, and are not discussed.

In addition, the book has its share of factual errors, misinterpreted statistics, and other blemishes. These probably will not do the lay reader much harm, but they could easily have been avoided.

CHRISTOPHER TIETZE

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LENGTH OF LIFE. *A Study of the Life Table. Second Edition.*

By Louis I. Dublin, Alfred J. Lotka and Mortimer Spiegelman. The Ronald Press Company, New York. $7.00. xxvi + 379 pp.; ill. 1949.

This is the second edition, much enlarged and thoroughly brought up to date, of the two senior authors' classical text on the life table, originally published in 1935. The first edition has long been out of print, and the new one will fill a definite need. Very skillfully the book combines offerings at different levels of complexity. For the educated layman it has a lucid presentation of the elementary principles of the life table and a chronicle of progress in the field of health and the prolongation of human life from the dawn of history to the present day. Social scientists and medical men will be able to obtain much useful information on the relationships between death rates and such factors as sex, age, marital status, race, occupation, heredity, and specific diseases. Demographers and public health workers will notice the new chapter on forecasts of mortality and longevity and the discussions on estimates of future population and on "generation" or "cohort" life tables. The detailed exposition of an abridged method of life table construction will be particularly useful to them. The connoisseurs will certainly enjoy the magnificent collection of almost one thousand life tables (e_x and q_x values) presented as an appendix to the volume.

Christopher Tietze

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Old People. *Report of a Survey Committee on the Problems of Ageing and the Care of Old People.*

Under the chairmanship of B. Seebohm Rowntree. The Nuffield Foundation, Geoffrey Cumberlege, Oxford University Press, London and New York. $1.50 (paper). viii + 202 pp. + 14 plates. 1947.

One of the objects of the Nuffield Foundation is the "care and comfort of the aged poor." To aid in implementing this object, a Survey Committee was appointed to look into the problems of ageing and the aged, and to consider what has been done and what might be done to alleviate them. The Committee's report, *Old People*, deals with the social status of the aged and with the measures being taken to improve it. That the information was obtained through leisurely interviews made by skilled field workers is reflected in the specific and detailed nature of the report. Almost half the book is given over to appendices presenting data relating to the questions raised by the text itself.

The first chapter of findings, dealing with the incomes of the old, reviews the development of public assistance and pension schemes in Great Britain. Under the National Insurance Act passed in 1946, 42s. weekly will be paid to a retired couple when the husband is past 65. Since this, as the report shows, is barely subsistence at present price levels, it is interesting that the sum, though diminished if the pensioner continues to earn, is increased when retirement does occur. The chapter on unemployment reveals that in 1945 a large majority of men between 65 and 75 were employed, except in the mining districts. According to employers, there are only a few industries in which places cannot be found that the elderly can fill as well as—and often better than—younger workers. The employment situation indeed seems better than the recreational situation, although one large club organization is described which has done much to relieve the boredom from which old men suffer.

The most depressing chapters are those that deal with housing conditions. Most of the elderly were found to be living under deplorable conditions, frequently without toilets or water. (But the evidence did indicate that the homes of the aged are not worse than those of younger members of the same classes.) Homes and institutions proved to be quite variable; but the number of well-staffed, well-run institutions was found to fall far short of the demand. Numerous specific recommendations are made for improving the housing and care of old people.

One gathers that the situation of the dependent aged is neither substantially better nor worse in Britain than in the United States. Hence the Nuffield Report should prove to be a valuable sourcebook to those in this country who want information on the various social facets of the steadily widening problem of old age.

Florence Moog

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Forecasts of the Population of the United States 1945–1975.

By P. K. Whelpton; assisted by Hope Tisdale Eldridge and Jacob S. Siegel; prepared under the supervision of Leon E. Truesdell. United States Department of Commerce, Bureau of the Census, Washington, D. C. 45 cents (paper). vi + 113 pp.; ill. 1947.

This is the fourth set of population projections or forecasts for the United States prepared by the staff of the Scripps Foundation, the first set having been published in 1934. The computations underlying the present edition were for the most part completed in the fall of 1945, a particularly unfortunate time for an undertaking of this nature. In the first place, the spectacular postwar "baby boom" was still in the future, and as a result even the projection based on the assumptions of "extra high" fertility, low mortality, and 200,000 immigrants per year (Table VII) has been far surpassed by the actual course of events. More important, much of the criticism leveled in recent years against the conventional net reproduction rate and population projections based on such rates had not yet been made, and none of the later improvements in technique (including certain very important contributions by Whelpton himself) were available. There can be no doubt that a fifth set of projections, if and when it is prepared, will be very different from its predecessors, although perhaps more in methodology than in the numerical results.

The analyses of the causes of the long-term decrease in fertility, of the short-term changes in birth rates, and of the implications of the expected trends in population growth and composition are most lucid and reasonable, and should be carefully read and studied by everyone interested in the demography of the United States.

CHRISTOPHER TIETZE

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1948 YEARBOOK OF FOOD AND AGRICULTURAL STATISTICS. *Including Notes in Spanish. Volume I. Production.*

Food and Agriculture Organization of the United States, Washington, D. C. $3.50 (paper). xviii + 285 pp. 1949.

This is a second volume of a series issued by FAO. Like the 1947 volume, it continues the statistical series on crops and numbers of livestock formerly published by the International Institute of Agriculture at Rome. Tables are presented showing area and production figures for the principal crops in the prewar period (generally 1934–38 averages) and in 1945, 1946, and 1947. The livestock numbers given are for the latest prewar year. This edition of the *Yearbook* also carries on the work of the International Institute of Agriculture by giving a series of tables showing in detail, for specified countries, the utilization of land for crops and the output therefrom, together with detailed classifications of livestock numbers by sex and age groups, wherever these are available. New to this issue of the *Yearbook* is the introduction of tables containing information on total population by countries and on the number of persons engaged in agricultural occupations. Tables have also been added on the production of condensed, evaporated, and dried milk. As a general rule, figures included in the tables of this *Yearbook* have been supplied by governments through special questionnaires, or have been taken from official government publications. It is likely that more recent and more objective information regarding special agricultural commodities can be obtained from the office of Foreign Agricultural Relations of the United States Department of Agriculture. This office has its own sources of information, and it is believed that its figures are more nearly correct and up to date than those contained in such a publication as this, compiled from official sources.

ROBERT L. PENDLETON

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FREEDOM FROM WANT: *A Survey of the Possibilities of Meeting the World's Food Needs. A Symposium. Chronica Botanica, Volume 11, Number 4.*

Edited by E. E. DeTurk, with a foreword by Norris E. Dodd. Chronica Botanica Company, Waltham, Mass.; Stechert-Hafner, New York. $2.00 (paper). Pp. 207–283; ill. 1948.

In an introduction, Norris E. Dodd views the future with hope. "After all," he says, "human understanding is itself a biological phenomenon and if it is given a chance to develop it is bound to make a difference in the way people act." To the reviewer, notwithstanding these words, Salter seems over-optimistic in his estimates of the productive capacity of tropical regions which are as yet not producing any considerable quantity of food crops. He has made the mistake of judging the potential productive capacity of the soils of the tropics on the basis of crop production in the Philippines; but those Islands have much better than average tropical soils. Black emphasizes that freedom from want is only relative, and "relative" is a very broad term. He shows that as undeveloped communities and nations modernize their economies, the rate of population growth can be brought within more reasonable limits. Tolley contends that such results can be achieved with knowledge and effort of both the physical and the social scientists if pooled in a concerted world-wide effort. Quisenberry, in telling of what has been accomplished by increasing crop production in the more advanced countries, suggests the future possibilities in other parts of the world. Morrison compares the relative efficiency of various farm animals as food for humans and some other considerations bearing on increased production. McCall emphasizes the need for better, quicker ways of getting scientific knowledge about improved land use into widespread use on farms. It should be noted that these papers were presented in 1946; and that FAO has an implied if not often stated date of 1960 for the time when world food supplies can be expected to catch up with the population. FAO seems to be silent about the more distant future.

ROBERT L. PENDLETON

BIOMETRY

PROBABILITY THEORY FOR STATISTICAL METHODS.

By F. N. David. Cambridge University Press, London. $3.50. x + 230 pp. 1949.

In this treatise the author states and proves in mathematical language those propositions and theorems of the calculus of probability which should be useful for students of mathematical statistics. The professional statistician or biometrician will find this an interesting work mainly because of its basic treatment of such topics as the evaluation of binomial probabilities by the incomplete B-function ratio, Laplace's theorem, the Poisson distribution, Bayes' theorem, the Markoff theorem, and so on. The book is much too technical and mathematical for most students in the biological sciences, who are interested in statistics only as a tool. It should, however, be useful as collateral reading for the occasional, rare student who comes to his first course in statistics with an excellent background in calculus.

A. CHAPANIS

STATISTICAL METHODS IN RESEARCH.

By Palmer O. Johnson. Prentice-Hall, New York. $5.00. xviii + 377 pp.; ill. 1949.

This book, in the reviewer's opinion, is one of the best, and very nearly one of the most complete, textbooks on statistical methods available to students of the biological and behavioral sciences. Especially noteworthy is its excellent and thorough treatment of the analysis of variance, covariance, and the small sampling techniques. Most of the problems and illustrative materials are taken from the psychological literature. It is refreshing to find at last a textbook in this area which does not use agricultural experiments as examples.

There is a chapter on the statistical analysis of data under non-normal assumptions and a good section on the use of transformations—two important topics which are treated lightly or not at all in many textbooks. The two chapters on the design of experiments are considerably more comprehensible than similar discussions by British statisticians. American students have long needed a reasonably understandable discussion of this highly important topic. There are, on the other hand, some rather conspicuous omissions in the book. Chi-square is given only a cursory treatment; and curve-fitting, a technique of great usefulness to the experimentalist, is not even mentioned.

This is an advanced textbook. The author assumes that the student has already had a course in descriptive statistics, and he recommends "at least a background in calculus." Even so, the text is considerably more difficult than it ought to be. It is hard to escape the feeling that when the author could have said something in either of two ways, he invariably chose the more involved and difficult one. Nonetheless, it is a comprehensive book, and it should be extremely valuable for those students who "can take it."

A. CHAPANIS

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STATISTICAL TABLES FOR BIOLOGICAL, AGRICULTURAL AND MEDICAL RESEARCH. *Third Edition Revised and Enlarged.*

By Ronald A. Fisher and Frank Yates. Oliver and Boyd, Edinburgh. 16s. viii + 112 pp. 1949.

The Fisher-Yates *Statistical Tables* need no introduction to statisticians and biometricians. The third edition of these highly useful tables has been improved mainly by a number of additions to and extensions of the tables in the second edition. Thus, 10 per cent points of z and e^{2z} have been added, orthogonal polynomials are now available for values of n' from 53 to 75, and the table of natural logarithms has been extended. Five other tables have been revised to increase their usefulness. One new table, giving the modified probit weighting coefficients necessary for dosage mortality tests involving deaths among controls, has been added.

A. CHAPANIS

DE OMNIBUS REBUS ET QUIBUSDAM ALIIS

THE ROYAL SOCIETY EMPIRE SCIENTIFIC CONFERENCE, JUNE–JULY 1946. *Volumes I and II.*

The Royal Society, London. £2 2s. 0d. (I) 828 pp. + 1 plate + 4 maps + 8 charts; text ill. (II) 707 pp. + 1 map; text ill. 1948.

This conference was held in London, Cambridge, and Oxford. Many of the leading scientists of the Empire presented papers which epitomized the work and progress in their respective fields in Great Britain or in their dominion or colony. Since space forbids even giving the titles of these papers, the subjects covered can best be indicated by the topics of the morning discussions: (a) a survey of some outstanding problems in agricultural science in the Empire; (b) a survey of some outstanding problems in medical science; (b-1) discussion of the physiological and psychological factors affecting human life and work under tropical conditions and in industry, (b-2) the etiology and control of infectious and transmissible diseases, particularly those which are insect-borne; (c) the present state of the science of nutrition with particular reference to the special problems of the Empire, including the nutritional status of the indigenous peoples of the Colonies; (d) modern methods of mapping and exploration by air, including the use of radio technique in ordnance survey, with special reference to particular parts of the Empire; (e) measures for improving scientific information services within the Empire, the subjects discussed including indexing, abstracting, special libraries, and microfilms; (f) methods of improving the interchange of scientists throughout the Empire, including a discussion on the future of the scientific liaison offices that have been established during the war; (g) Empire cooperation in the scientific field with existing and projected international organizations; (h) measures which might be taken to secure greater uniformity in physical standards of measurement and the use of units, terms, and symbols; (i) the collection and interchange of scientific records and experimental material, including the safeguards that will have to be taken to minimize the risk involved in the distribution of plants, seeds, and animals; (j) the problems of land utilization and conservation throughout the Empire, bringing together the various factors affecting land utilization and conservation including forestry, soil erosion, irrigation, etc.; (k) the need for a coordinated survey of the mineral resources of the Empire and for operations on a much larger scale than hitherto; (l) the natural products of the Empire and the chemical industries that are or might be based on them; (m) post-war needs of fundamental research; (n) an all-African organization for the coordination of scientific work within the African Continent. Fortunately these volumes have relatively detailed indices which make it possible to discover and to refer to much of the enormous range of information contained in them.

ROBERT L. PENDLETON

STUDENT'S HANDBOOK OF SCIENCE.

By Bernard Udane and Herman W. Gillary. Frederick Ungar Publishing Company, New York. 75 cents; 60 cents per copy for ten or more (paper). 208 pp.; ill. 1948.

This book has been prepared by two science teachers in the Forest Hills High School in New York City to meet the need for guidance of science students. Paul Brandwein, Chairman of the Science Department in this school, says in the Foreword: "This little book should be in the hands of every science student—not because all science students are to be scientists but because all of them need to know whether they are fitted for a science career, whether they are getting the most out of their work in science, whether they can improve their study habits, and how science can contribute to their enjoyment of living." Not only will this book be of great service to the science student, it should also be an invaluable aid to the busy teacher because it will offer guidance which would require hours upon hours of the teacher's time to render to each individual student. Furthermore, this guidance will be from experts who have placed more winners in the annual Westinghouse Science Talent Search than any other single group of teachers in the nation.

The book is divided into four parts: I) How You Can Prepare for a Career in Science; II) How You Can Get a Good Start in Your Science Career; III) How You Can Be a Better Science Student; IV) How You Can Develop Your Science Interests at Home.

Part I lists 100 vocations related to science and 56 publishers of pamphlets on these vocations. Aptitude tests and scholarships are also discussed in detail. Parts II and III show the student how to plan his program in detail, how to make drawings and take notes, how to make a science report, how to carry on many extracurricular science activities, how to keep a good notebook, how to use the library, how to keep abreast of science news with current science magazines, etc. Part IV will help any interested students to develop a science hobby even though they may not be planning to enter upon a science career. Hobbies discussed include: nature study, bird watching, entomology, plant studies, microscopy, photography, astronomy, geology, meteorology, radio, and several more. This Part concludes with chapters on purchasing science supplies and building a science library. The Appendix gives information on culturing and caring for laboratory organisms, on taxonomy, a table of elements, common formulas, temperature scales, equations, and other useful material. Busy teachers and interested students owe a real debt to these authors for making available at last a useful and well organized book of this kind.

ELLA THEA SMITH

PRÉCIS DE MICROSCOPIE: *Technique, Expérimentation, Diagnostic. Seventh Edition.*

By M. Langeron. Masson et Cie., Paris. 2600 fr. viii + 1430 pp.; ill. 1949.

There is no single equivalent written in the English language to M. Langeron's standard French work on all aspects of biological laboratory technique which involve the use of the microscope. The book consists in reality of three sections which are largely independent. The first of these (353 pages) deals with the optical and mechanical principles of the microscope, with chapters on special topics such as dark-ground illumination, phase-contact and ultra violet microscopy, micromanipulation, photomicrography, camera-lucidas, etc. This part of the book, with certain reservations to be noted later, is very well done, the theoretical sections on the optical principles of the various methods being interspersed with practical hints, written from the standpoint of a laboratory scientist who really knows how to get the most out of the equipment he uses. Naturally, the instruments described and figured are almost exclusively those provided by European manufacturers, the microscopes of Zeiss and Stiassnie (Paris) being conspicuous. This does not detract in any way from the value of the theoretical discussion to American readers, but a good many of the practical hints are hardly applicable to the equipment used in American laboratories. The sections on phase-contrast and electron-microscopy are somewhat weaker than the rest of this section of the book, being written from the standpoint of pure theory rather than from that of practical experience. Even here, however, the theoretical discussions are admirably clear and easy to follow. The chapter on micromanipulators is devoted largely to a description of the instrument of de Fonbrune, a very superior type of microdissection apparatus developed recently in France, and one which should be more widely known and used in this country. In contrast to this, the chapter on photomicrography is a complete disappointment, since the author appears to suffer from the curious delusion that the only way to get good photomicrographs is to use a "Universal Microprojector" invented by a certain Dr. Leroux (there is no mention of the many types of excellent photomicrographic cameras manufactured in this country and in pre-war Germany).

The second section of the book (400 pages) deals with histological technique. In a general way this corresponds to the well-known "Microtomist's Vade-Mecum," but the principles underlying the methods are much more fully explained. The chapters dealing with section-cutting are as concise and clear as those in the first part of the book, and the techniques recommended for fixation and staining are not so very different from those in general use in this country.

The third part of the book is entitled Special Methods. It deals with techniques suitable for the microscopical study of all types of organisms from amebas and bacteria to the higher animals and plants—there is even a paragraph on special histological methods for studying the tissues of mummies. This part of the book is especially aimed at the medical reader, particular attention being devoted to methods used in parasitology, hematology, and even in medico-legal practice. The section on entomological techniques deals in considerable detail with the insects which are important in medical entomology, methods for rearing mosquitoes, lice, and fleas being fully explained. Histochemical reactions receive a very adequate treatment. Cytological techniques used for the study of the cytoplasm are fully described, but the section on chromosome cytology is completely inadequate and so brief as to be almost unintelligible.

In many respects "Langeron" has an antique flavor, coming from a country where many modern aids to scientific work are unknown or unobtainable. To members of the French medical profession (especially those working in the isolation of the French colonies) it must be an invaluable work. To those of us fortunate enough to be working in well-equipped American laboratories (and who necessarily rely largely on handbooks and instruction manuals supplied by the makers of the instruments we use) it will be less useful. But almost every working biologist could find much valuable and pertinent technical information in this most comprehensive work.

M. J. D. White

* * *

THE ORIGIN OF MEDICAL TERMS.

By Henry Alan Skinner. The Williams & Wilkins Company, Baltimore. $7.00. viii + 379 pp. 1949.

Quite a number of books try to bridge the gap between the continuous necessity of using a special terminology and the ever increasing illiteracy of our students. There are the big medical dictionaries with innumerable short references to all possible terms. There are also the more detailed books on anatomical nomenclature, which does seem to be more of a problem to the student than the rest of medical terminology, primarily because he clashes with it first. Skinner's dictionary is superior to many other attempts in the same direction because it includes all medical terms, and not only the anatomical ones. Furthermore, it tries to explain not every term or name, but restricts itself to the essential ones, giving them in exchange a more thorough treatment. The book is factually sound, well selected, and well written. The occasional inclusion of such proper names as were not used for eponyms or whose owners were not of decisive importance in the history of medicine (like Alhazen, Amuzat, Balard, Bellini, Berengarius, etc.) seems superfluous. The student can look up such names in current medical history reference books, like those by Garrison or Mettler. Medical students and doctors will consult this volume with profit as well as pleasure.

Erwin H. Ackerknecht

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BLAKISTON'S NEW GOULD MEDICAL DICTIONARY. *A Modern Comprehensive Dictionary of the Terms Used in All Branches of Medicine and Allied Sciences, Including Medical Physics and Chemistry, Dentistry, Pharmacy, Nursing, Veterinary Medicine, Zoology and Botany, as Well as Medicolegal Terms.*

Edited by Harold Wellington Jones, Normand L. Hoerr and Arthur Osol; with the cooperation of an Editorial Board and Eighty Contributors. The Blakiston Company, Philadelphia and Toronto. $8.50. xxviii + 1294 pp. + 45 plates. 1949.

STEDMAN'S MEDICAL DICTIONARY *of Words Used in Medicine With Their Derivations and Pronunciation Including Dental, Veterinary, Chemical, Botanical, Electrical, Life Insurance and Other Special Terms; Anatomical Tables of Titles in General Use, the Terms Sanctioned by the Basle Anatomical Convention; the New British Anatomical Nomenclature; Pharmaceutical Preparations Official in the U. S. and British Pharmacopoeias or Contained in the National Formulary; and Comprehensive Lists of Synonyms; Biographical Sketches of the Principal Figures in the History of Medicine. Seventeenth Revised Edition With Etymologic and Orthographic Rules.*

Edited by Norman Burke Taylor; in collaboration with Allen Ellsworth Taylor. The Williams & Wilkins Company, Baltimore. $8.50 (with thumb index); $8.00 (without thumb index). xliv + 1361 pp. + 6 plates; text ill. 1949.

Advances in every branch of medicine and the basic sciences related to it have enlarged the terminology whereby these advances are described. New words and new meanings for old words have never been coined so abundantly as in recent years. New, up-to-date dictionaries are essential for anyone who would be accurately informed concerning things medical. These two dictionaries are intended to fulfill this purpose.

The *New Gould Medical Dictionary*, although stated to be a first edition, is the successor of the original Gould published in 1890 and followed by nine new editions, including this one, four of them labeled "first." Eighty contributors aided the three chief editors. Special tables of arteries, enzymes, vitamins, and monstrosities are included. An atlas of 252 illustrations, 129 in color, deals mainly with anatomical, blood, bacterial, and parasitological subjects. An appendix of 135 pages includes tables dealing with data anatomic, blood, dietary, enzymic, hormonal, vitamin, therapeutic materia medica, etc. An earnest effort to follow the best etymological practices is claimed by the editors. They have, they say, "diligently searched recent professional literature not only for new terms but also for evidence of the changes in usage which they felt were evident today. . . . More than three hundred standard modern texts reflecting current usage and nomenclature in all the basic fields of medicine, surgery and the biologic sciences as well as recognized journals, yearbooks and standard indexes of many specialties were critically and systematically examined." Biographical sketches of contributors to medical science and literature are given throughout the text.

In the new *Stedman's Medical Dictionary*, the editors have endeavored to delete "dead wood," revise outmoded definitions, and add new ones. Trade names have been deleted. In this edition, short biographical notes on the principal figures in the history of medicine are included in appropriate definitions of diseases, procedures, or discoveries. An appendix deals mainly with a comparative list of anatomical terms (Latin, B.N.A., and Anatomical Society of Great Britain), weights, measures, temperature scales, etc. Line cuts, half-tone, and color inserts are found generously throughout the text.

In evaluating a dictionary, a reviewer must do so in the field of his own particular competence. With this limitation, a careful comparison of these two volumes had been made with respect to the physiology of reproduction and gynecic physiology. It was reassuring to find an exceedingly high degree of accuracy in the new Stedman's. This was not true, repeatedly, in the case of the New Gould. A few examples will suffice to illustrate the point. *Alphaestradiol* is defined simply as *estradiol*. Under *estradiol*, *alphaestradiol* is correctly listed as "the active isomer of estradiol." The three indicated pronunciations for *estradiol* will leave the uninitiated at a loss as to which is common or preferred. *Progestin* is incorrectly stated to be a trademark name for a brand of *progesterone*. The name *progestin* was agreed upon by a Committee of the League of Nations to be reserved for all tissue extracts having demonstrable progestational activity. The value and wisdom of including *progestone* and *progestoral* as trademarked names of proprietary preparations is questionable. *Progestational* is stated quite incorrectly to be obsolete; *progravid*, it is said, is now preferred. These are but a few of numerous similar points that were noted in perusing this dictionary for one evening.

With respect to biographical references, both dictionaries leave something to be desired. In the first place, a definite policy should be adhered to with respect to the inclusion of biographies. Thus, the New Gould gives a sketch of Visscher of the Visscher-Bowman pregnancy test (a test little used nowadays), but not of Bowman. No sketch is given of Friedman, although this test is still one of the most widely used tests for pregnancy. Lapham, of the Friedman-Lapham test, is not mentioned. Again, sketches of Ascheim and Zondek are given, but none of Smith and Engle, whose discoveries with respect to gonadotrophic hormones are no less important than, and were concurrent with those of the former investigators. In Stedman's, two mistakes in the names of living individuals were found in the first six that were looked up. The merit of such references in either dictionary appears dubious, to say the least.

S. R. M. REYNOLDS

◆

A MENCKEN CHRESTOMATHY.

Edited and annotated by H. L. Mencken. Alfred A. Knopf, New York. $5.00. xvi + 627 pp. 1949.

It is said that some Baltimore mothers used to threaten their misbehaving children, not with the usual bogeyman, but with "Mencken will get you if you don't be good!" I also have it, and on equally good authority, that such treatment, depending of course on the constitution and age of the infant, could interfere with its normal feeding process, thus leaving the child with a feeling of insecurity. This, in turn, could result in memory impressions that would ultimately make the unconscious a dynamic center of psychic energy rather than a bin of harmless impressions. This, as probably everyone knows, can produce an anxiety, and if repeated frequently enough, can establish at a very early age definite psychopathology. Some students of the subject, particularly those prone to premature conclusions, hold that such a series of events accounts for what they loosely describe as the "Baltimore Neurosis." To attribute this psychic manifestation, especially one of such a broad nature, as being solely due to the fact that some children were frightened by the threat of Mencken is, I think, an oversimplification of the problem. I know of a case where an older son was required to mind his younger brother during their parents' absence. Oftentimes he put him to sleep by reading aloud Mencken's *In Defense of Women*. The fact that the young one turned out to be a clinical endocrinologist specializing in male sterility would only be offered as supporting evidence for the above hypothesis by those so biased that they regard clinicians in any form as individuals with warped or hysterical personalities. I view with alarm such facile generalizations, on the ground that it gets us nowhere.

A second consideration bearing on the general question of H. L. Mencken and his ideas is his education, or rather lack of one. It is amazing to some that so many people accept as the absolute truth everything coming from Mencken, despite the fact that the man has no Ph.D., no M.A., not even an A.B. degree. A deficiency of this magnitude certainly disqualifies him as an authority on questions secular, sacred, or scientific. Furthermore, and he openly boasts of it (p. 132), he never went to college! This lack of a university education shows up strikingly in his comments on a wave of suicides that occurred among college students back in 1927. I quote:

> "What I'd like to see, if it could be arranged, would be a wave of suicides among college presidents. I'd be delighted to supply the pistols, knives, ropes, poisons and other necessary tools. Going further, I'd be delighted to load the pistols, hone the knives, and tie the hangman's knots. A college student, leaping uninvited into the arms of God, pleases only himself. But a college president, doing the same thing, would give keen and permanent joy to great multitudes of persons. I drop the idea, and pass on." (p. 133).

I am quite sure that if Mr. Mencken had spent even one semester in college, he would never entertain such ideas. I am equally sure that even in his freshman year he would have realized that all, well, practically all, college presidents have been picked primarily for their scholarship, ability, and integrity. Furthermore, if he showed any capacity for observation, he would very quickly see that all, well, practically all, of the faculty hold college presidents in the highest regard, and they would probably not derive any keen and permanent pleasure from such mass suicides (though it may be of great interest to those academically concerned with the phenomena of mass physiological and psychological behavior patterns).

Another example of Mencken's faulty education is his suggestion to abolish all the sorrows of the world by the "... simple device of getting and keeping the whole human race gently stewed." (p. 389). This idea, pleasant though it may be, is fraught with many difficulties, principally of a technical nature. If Mencken had gone to college and taken courses designed for the education of the Scientific Generalist (see *Science* 109: 553. 1949), it is probable that he would have been capable of offering some concrete methods on how this condition could be brought about. His simple suggestion that this can be accomplished by impregnating the air with alcohol and, with no further ado, leaving all the technical details to be worked out by men "skilled in therapeutics, government and business efficiency" is typical of the ignorant, and reminds many of the professional promotors of societies that promise, on the morrow, cures for cancer, polio, and other chosen diseases. Furthermore, the suggestion of using grain alcohol shows a complete disregard for individual variations in taste and ignores the fact that there are large groups who prefer blended distillates from Scotland. This narrow, undemocratic, and antisocial attitude is said to be typical only of those individuals who did not go to college.

It is highly probable that a college education would improve Mencken. If going to college is not possible for him, attendance at a good junior college, or maybe even Yale, would help. Had he done this in his earlier years, he would have altered many of the ideas that he sets forth in his *Chrestomathy* (which, as practically every college graduate knows, means a collection of choice essays).

It is customary, when a reviewer is greatly pleased with a book, to recommend it highly for the consideration of readers. This must be deferred until it is determined whether such action in this case makes one liable under Maryland's anti-subversive laws.

David B. Tyler

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THE QUARTERLY REVIEW of BIOLOGY

SPECIATION IN ANCIENT LAKES

(CONCLUDED)

By JOHN LANGDON BROOKS

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SPECIATION IN THE AFRICAN RIFT LAKES

ONLY two lakes existing today resemble Baikal in both morphology and magnitude. These are the African Rift Lakes, Tanganyika and Nyasa. As the fauna of each is known to include species flocks, these lakes are also of immediate concern to us.

Description of Lakes Tanganyika and Nyasa

Like Baikal, Lakes Tanganyika and Nyasa each occupy tectonic troughs and all have many similar features. All are very long and narrow. The long axis of Tanganyika measures 650 km., whereas that of Baikal is 675 km. Their areas and therefore their average widths are practically identical (Halbfass, 1928). Nyasa is shorter, 580 km. in length, but about as wide, with an area of 25,000 sq. km., according to Gillman (1933). Baikal, Tanganyika, and Nyasa are respectively the seventh, eighth, and ninth largest in area of the lakes of the world (Halbfass, 1937).

A bathymetric map of Tanganyika was published by Stappers in 1914. Rhoades' map of 1902 is the only one available for Nyasa. (Stappers' map is reproduced in Beauchamp, 1939, and in Poll, 1946.)

In Tanganyika the maximum depth which has been found is 1435 m., proving this to be the second deepest lake in the world. Tanganyika is separated into two major basins by a ridge joining the large peninsulas jutting into the middle part of the lake. The position of the ridge is indicated by the arrows in Fig. 6. Dr. Max Poll, of the Congo Museum, Tervuren, has graciously informed me in personal communication that echo-soundings made by Dr. A. Copart, oceanographer of the recent Belgian expedition to Tanganyika, indicate that this ridge between Kungwe and Albertville has a mean lower depth ("profondeur moyenne inférieure") of 500 m. At one of Stappers' soundings the ridge was within 136 m. of the present surface. The southern basin is the larger, and the maximum depth was found somewhat south of its middle. The maximum depth recorded from the central basin is 1277 m. The greater part of the bottom of the third, much smaller basin which forms the northern tip of the lake is about 200 m. below the surface. The only major irregularity in the present Tanganyika coastline is the J-shaped Ubwari Peninsula which juts from the west shore at the northern end of the lake and separates the northern from the central basin. The long arm of the peninsula runs northward parallel to the shore and encloses the relatively shallow (to about 200 m). Gulf of Burton.

Nyasa is not as deep as its northern sister, ranking as fourth deepest of the world's lakes, with a maximum depth of 706 m. (Halbfass, 1937). Most of the bottom in the southern half of Nyasa is between 100 and 350 m. below the surface,

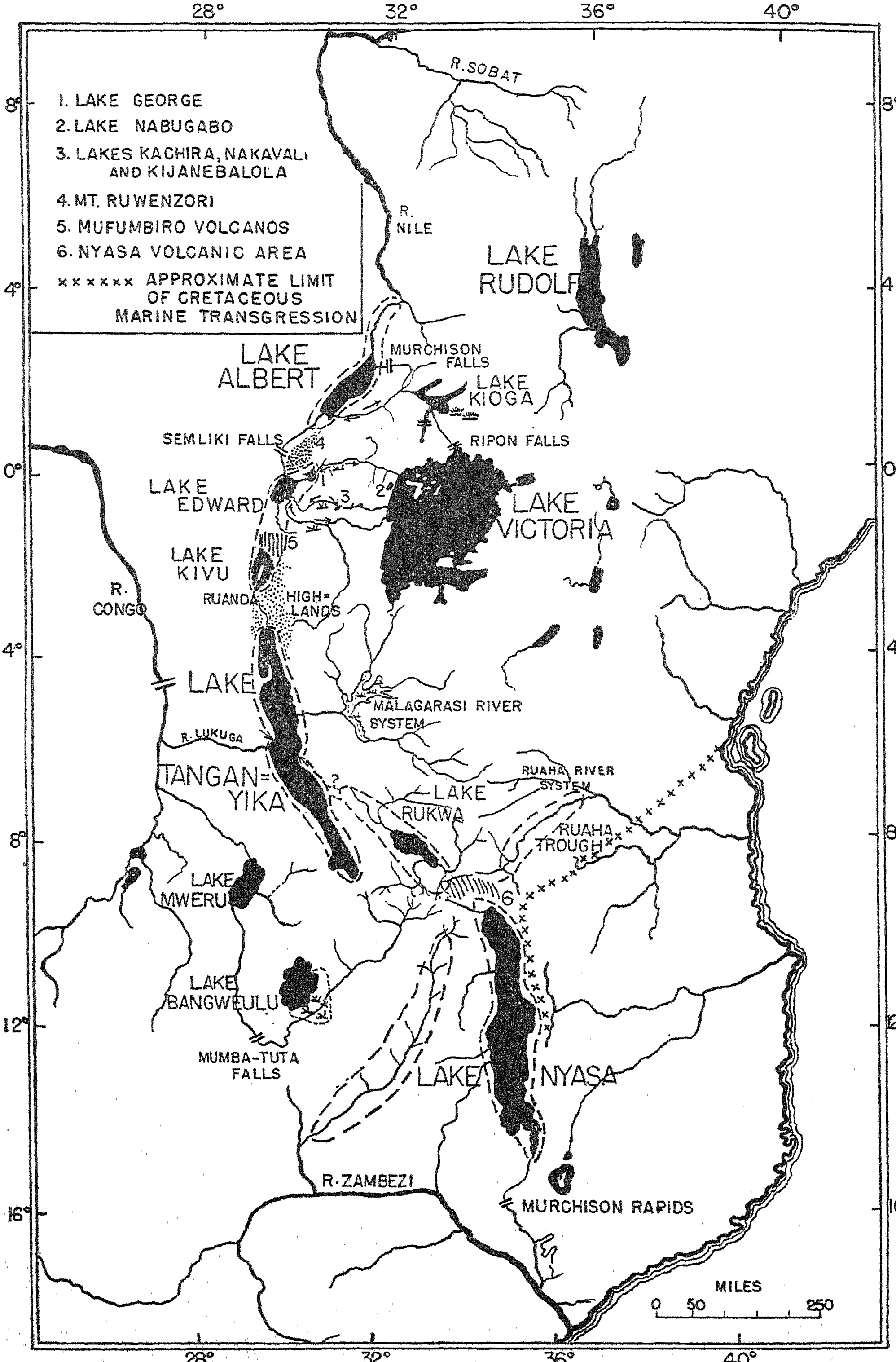

FIG. 6. EAST AFRICAN LAKES AND THEIR HYDROGRAPHIC CONNECTIONS
The major geomorphic features essential to an understanding of the history of the lakes are indicated.

while in the northern half most of it is deeper than 300 m. There are no indications of submerged ridges subdividing the lake basin.

Although these two African lakes are morphometrically similar to Baikal, the dissimilarity of their thermal properties causes a markedly different distribution of life within them. The difference in latitude between Baikal and these two lakes, which lie between 3°S. and 15°S. at elevations of less than 800 m., is the primary cause of the dissimilarity. A brief discussion of the physics and chemistry of Tanganyika and Nyasa must therefore precede a consideration of their biotas. The only satisfactory hydrological study of these lakes on which such a study can be based is that done by Beauchamp in the late 1930's and published in 1939, 1940, and 1946.

The temperature of both Tanganyika and Nyasa is permanently above 4°C. and the deep layers are stagnant, cut off from the freely circulating upper layers, and therefore without oxygen. The waters of Tanganyika below 300 m. are always at 23.1°C. During the summer the upper 60-meter layer reaches a temperature of 25.75°C. At the bottom of this freely circulating layer, or epilimnion, the temperature drops rapidly with increasing depth. Between 60 and 80 m. it drops from 25.75 to 23.75°C. This water level of rapid temperature change with depth in a stratified lake is called the thermocline. The depth of the thermocline varies between 40 and 100 m. in different parts of the lake. A lake is stratified if the buoyance of the warmer upper layers is so great that the wind cannot push this lighter water into the denser, cooler water below, thereby mixing them. The density difference between water at 26°C. and that of water at 23°C. is as great as that between waters of 16°C. and 10°C. Below 80 m. the temperature drops slowly to the minimum, 23.1°C., at 300 m. Tanganyika is stratified for eleven months of the year. The surface waters lose heat during the winter, becoming less buoyant and capable of being submerged by the wind to greater depths. At the time of maximum mixing the temperature drops steadily from 25°C. at the surface to 23.7°C. at a depth of 125 m. From this depth down to 300 m. the temperature slowly decreases to 23.1°C. The surface waters at 25°C. are still sufficiently less dense than the deep waters just above 23°C., so that the wind cannot mix them.

The vertical distribution of dissolved oxygen within the upper 100 meters of water is seasonally variable, but below this depth the water is always devoid of oxygen. During stratification the epilimnion contains 7 p.p.m. O_2—85 per cent saturation. A few meters below the bottom of this circulating layer the water is oxygen-less. This sets a sharp lower limit to the distribution of aerobic organisms during this period. At the time of maximum mixing the oxygen content drops rapidly from 7.5 p.p.m. at the surface to one third of one p.p.m. at 90 m. This rapid diminution in O_2 concentration with increasing depth within the freely circulating waters is due to the mixing of water oxygenated at the surface with the oxygen-less water between 60 and 100 meters. This means that for organisms living in the upper 60 meters less oxygen will be available in the months of mixing than during the period of stratification. For example, the open waters at a depth of 50 m. contain 7 p.p.m. O_2 in the summer and only 4 p.p.m. in the winter. At 70 m., on the other hand, no oxygen is available during stratification, and at the time of maximum mixing the oxygen concentration has only reached 3.5 p.p.m.

The thermal regime of Nyasa is sufficiently different from that of Tanganyika to merit individual treatment. The water below 300 m. is isothermal but one degree cooler than the Tanganyika minimum. The surface waters reach a temperature of 27°C., over one degree warmer than Tanganyika. During this period of stratification the drop in temperature at the bottom of the epiliminion is less abrupt here, but the thermocline is well marked. Between 40 and 65 m. the temperature drops from 26.3°C. to 23.7°C. It drops at an ever decreasing rate below this depth to the minimum at 300 m. At the time of its maximum the freely mixed layer, isothermal at 23.3°C., is 100 m. thick.

The more extensive mixing of the waters of Nyasa is attributed by Beauchamp to the winds playing over the lake, which are not only stronger than those on Tanganyika but also more variable in direction. The latter circumstance is of considerable significance because of the greatly increased turbulent mixing of the upper layer of the hypolimnion induced by the changes in the rate and direction of flow of the water at the bottom of the epilimnion.

This induced turbulent mixing of the water between 60 and 200 m. results in a vertical distribution of oxygen quite different from that in Tanganyika. The epilimnion contains about 6 p.p.m.

O_2 during summer stratification. Below 60 m. the concentration gradually drops to very near zero at 200 m. Water at a depth of 150 m. contains 3.5 p.p.m. O_2 under these conditions. At the maximum mixing the upper 100 m. have over 6.5 p.p.m. of dissolved oxygen, and at 150 m. there are 5.5 p.p.m. Below this depth, however, O_2 concentration drops rapidly to 1 p.p.m. at 200 m. Traces can be found as deep as 275 m. At a depth of 180 m. there are 2 p.p.m. O_2 present in the open waters throughout the year. Thus the depth to which aerobic organisms in Nyasa can descend is much greater than in Tanganyika.

As both Tanganyika and Nyasa are situated on the boundary between subarid and subhumid regions, there is reason to believe that in prehistoric times, as in the past century, the lakes have alternately possessed and lacked outlets, depending upon the water level (Gillman, 1933). Tanganyika is nearer to the subarid region, and it is a bit surprising that the accumulation of solutes in its water is not greater than it is. The salt concentration is 400 p.p.m. (Beauchamp, 1939). There is no evidence that either the total concentration of solutes or the proportion of the ions has had any important effect on the lake's biota, either by the exclusion of any faunal elements or by influencing the process of speciation. Beauchamp's suggestion (1940) that large amounts of potassium and magnesium may have caused the development of some of the species peculiar to the lake is very improbable. The water of Nyasa is more like that of Baikal in its low salt concentration.

The Nyasan Fauna

The dominant elements of the Nyasan fauna are fish and molluscs, according to Moore (1903). Less conspicuous but exceedingly numerous are chironomid larvae whose adults form huge clouds over the surface of the lake at certain times of the year. As these emergences usually occur just after the period of the mixing of oxygenated water to greater depths, it is reasonable to assume that a large part of the population of chironomid larvae lives in relatively deep water (Beauchamp, 1940).

The taxonomy of the gastropod and pelecypod molluscs of Nyasa has long been in a chaotic state, and no modern revision has been made. Pilsbry and Bequaert (1927) have provisionally assigned most of the snails of Nyasa to the genus *Melanoides*, a group widely distributed throughout the tropics of the Old World. It is almost impossible to ascertain the number of species in this flock, although Cunnington (1920) has concluded that there are seven endemic species. The pelecypods are represented by seven endemic unionids and four endemic mutelids (Cunnington), but their generic status is uncertain.

The taxonomy of Nyasan fishes has been extensively studied. Recently Trewavas (1931, 1935) has revised the cichlids, and Worthington (1933) has brought out knowledge of the other families up to date. Ricardo-Bertram, Borley, and Trewavas (1942) introduced slight modifications into the cichlid taxonomy, according to Poll (1946), but their paper was not available to this reviewer. The systematic distribution of the Nyasan fishes is summarized in Tables 4 and 5.

The cichlids have speciated out of all proportion to representatives of other families. There are 174 endemic cichlids in Lake Nyasa, all but five of which are related to *Haplochromis*, a genus also found in other African freshwaters. One hundred and one are placed in this genus; the more divergent species are distributed in 20 endemic genera. Many species of this flock have a characteristic color pattern rarely seen in non-Nyasan species. Regan (1922) stated: "The indications are that the endemic Nyasa cichlids have originated in the lake from about half-a-dozen ancestral forms." All but a single species of *Haplochromis* (*H. callipterus*) are closely related and undoubtedly form a species flock together with several monotypic genera created for highly divergent species whose *Haplochromis* affinities are still evident (Regan, 1922; Trewavas, 1935). The 24 species of *Lethrinops*, all of which feed on bottom-living insect larvae, constitute another species flock. The 23 species which are abundant among the rocks on the rocky stretches of shore, and which Trewavas (1948) has called rockfish, are clearly related to each other, although placed in nine genera (*Pseudotropheus* (11), *Petrotilapia* (1), *Cyathochromis* (1), *Cynotilapia* (1), *Labeotropheus* (*1*), *Christyella* (*1*), *Melanochromis* (5), *Genyochromis* (1), *Labidochromis* (1), forming a species flock). The eight members of *Rhamphochromis* are open-water predators (Trewavas, 1948).

The five endemic Nyasan cichlids not related to *Haplochromis* belong to the non-endemic genus *Tilapia*, but constitute an indisputable species flock, as Trewavas has shown. In her 1948 paper, Trewavas emphasized the inapplicability of Mayr's hypothesis of multiple invasion in explaining the origin of these Nyasan species flocks.

The cyprinid genus *Barbus*, with eight endemic species, is the only large non-cichlid species association, part of which may represent a species flock which has developed within the lake from a single stock. However, the presence of six non-endemic species of *Barbus* in Nyasa makes it necessary to consider the possibility of multiple invasions as an explanation of the endemic as well as the non-endemic species. This is discussed subsequently.

Development of Lake Nyasa and origin of its fauna

Two differences between Lakes Baikal and Nyasa are apparent. First, the paucity of animal groups in Nyasa compared with Baikal is striking. Second, most of the Nyasa populations judged specifically distinct are still sufficiently like their relatives outside the lake to be retained in non-endemic genera. Only among the cichlid fishes are there endemic genera, although about half of the species of fish of other families and all of the gastropods and pelecypods are endemic. This contrasts with the Baikalian fauna, of which only a few endemic species of fish exhibit sufficient relationship to non-Baikalian species to be placed in the same genera.

The explanation of the lack of divergence of the Nyasan fauna from that of the common fauna of African freshwaters is to be sought in the details of development of the lake basin. Most of our knowledge of the geological history of Lake Nyasa is based on the work of Dixie, who has investigated this region over the past twenty years. In his opinion Lake Nyasa had its origin in a small lake in the northern part of the present basin. Here three series of deposits, in part lacustrine, are exposed well above the present lake level. The mammalian fossils of the middle (Chiwando) beds contained mastodon and hippopotamus remains (Hopwood, cited in Dixie, 1927), and on this evidence Dixie (1941) has placed the origin of Lake Nyasa about Middle Pleistocene. As the length of the Pleistocene is estimated at one million years on the basis of radioactive determinations (Zeuner, 1946), the age of Lake Nyasa is of the order of 500,000 years. Similar estimates have assigned 70 million years to the Cenzoic, so that Lake Baikal is of the order of 50 million or more years old, at least ten times as old as Nyasa.

The original, small Lake Nyasa is believed by Dixie to have stood some 750 meters above the present lake level. Through faulting and erosion its level was lowered by stages and it elongated southward. Downthrusting of the southern half of the present basin resulted in the extension of the lake to its present southern limits.

According to the interpretation of Dixie (1939), the Nyasa-Shire trough was a valley as long ago as early Cretaceous, and apparently was part of a drainage system of which the modern Zambesi is the direct descendant. This is in accord with the zoogeographic evidence, for the affinities of the fish in Nyasa are all with the Zambesi and the rivers of East Africa, with no indication of affinity with the Congo Basin.

The six species of molluscs which Connelly was able to find in the fossil material from the Chiwando beds are in no wise remarkable, as they are forms still widely distributed in African freshwaters (Connelly, cited in Dixie, 1927).

The harpacticoid copepod genus *Schizopera*, with a single endemic species in Nyasa, is the only element of this lake's fauna which cannot be ascribed to the African freshwater fauna. This genus occurs in widely scattered coastal brackish water the world over and has been discovered in freshwater situations of both Italy and Sumatra. The *Schizopera* problem also arises in connection with Lake Tanganyika.

Distribution and Speciation in Nyasa

The presence, in a lake as young as Nyasa apparently is, of several large species flocks, one of them the largest found in any lake, indicates relatively rapid cleavage of the original populations. As the evidence in Baikal has demonstrated the probability that intra-lacustrine geographical isolation is responsible for such cleavage, we must examine the possibilities of geographical isolation within Nyasa.

Moore (1903) observed at the end of the last century that the Nyasan fauna, which he considered to be composed of crocodiles, fish, and molluscs, was restricted to a narrow littoral zone running around the lake. This habitable zone is shallow, for Moore was unable to find any organisms living below 35–50 m. The distribution of the fauna, particularly the molluscs, along this narrow strip of shore is unequal, as is clearly brought out in Moore's words:

> "Thus the Molluscs in Nyasa live chiefly in the sheltered bays and creeks which communicate with the open body of the lake, each bay forming in itself a colony wherein a number of molluscs live practically

TABLE 4

Synopsis of fish faunas of Lakes Tanganyika, Nyasa, and Victoria

P = Species Present but not Endemic; E = Endemic Species; GE = Endemic Genus; * = Endemic Genus.

FAMILIES	LAKE TANGANYIKA	LAKE NYASA	GENERA IN TANGANYIKA	GENERA IN NYASA	VICTORIA NYANZA
Protopteridae	1P		*Protopterus*		1P
Polypteridae	1P		*Polypterus*		
Clupeidae	2E (2GE)		* *Limnothrissa* * *Stolothrissa*		
Mormyridae	6P	5P, 1E	*Mormyrops*, *Marcusenius* 2, *Gnathonemus* 2, *Mormyrus*	*Marcusenius*, *Gnathonemus* 2, *Mormyrops*, *Petrocephalus*, *Mormyrus*	2P, 4E
Characinidae	5P, 1E	1P	*Hydrocyon*, *Alestes* 3, *Micralestes* 2	*Alestes*	
Citharinidae	1P, 1E		*Citharinus*, * *Distichodus*		1P, 1E
Cyprinidae	7P, 7E	8P, 14E	*Barbus* 6, *Varicorhynchus* 2, *Labeo*, *Barilius* 3, *Engraulicypris* 2	*Barbus* 14, *Varicorhynchus*, *Labeo* 4, *Barilius* 2, *Engraulicypris*	4P, 10E
Bagridae	2P, 8E (2GE)	1E	*Bagrus*, * *Chrysichthys* 5, * *Phyllonemus* 2, *Lophiobagrus*, *Auchenoglanis*	*Bagrus*	1P, 1E
Mochocidae	1P, 4E	1P	*Synodontis* 5	*Synodontis*	2E
Amphiliidae	1P	1P	*Amphilius*	*Amphilius*	
Schilbeidae	1P	1P	*Schilbe*	*Eutropius*	1P
Clariidae	4P, 2E (2GE)	4P, 2E	*Clarias* 3, *Heterobranchus*, * *Dinopterus*, * *Tanganikallobes*	*Clarias* 6	4P, 2E

Malapteruridae	1P	1P	*Malapterurus*	*Malapterurus*	
Cyprinodontidae	1P, 2E (1GE)	1P, 1E	*Aplocheilichthys*, * *Lamprichthys* 2	*Aplocheilichthys*, *Nothobranchius*	2P, 1E
Centropomidae	4E (1GE)		*Lates* 2, * *Luciolates* 2		
Anabantidae	1P	2P	*Ctenopoma*	*Ctenopoma* 2	1P
Mastacembelidae	1P, 6E	1E	*Mastacembelus* 7	*Mastacembelus*	1E
Cichlidae	2P, 89E (34GE)	4P, 174 E (20GE)	See Table 5	See Table 5	5P, 58E, (3GE)
Total No. Families	18	13			12
Total No. Genera	79	44			25
Total No. Endemic Genera	42	20			3
Total No. Species	162	223			103
Total No. Endemic Species	126	196			80

isolated from the other colonies which are distributed around the shore. Storms and floods effect the dispersion of members of these colonies at different times and in this way every colonisable area of the lake becomes filled with molluscs, but in general the individual population of each colonisable area remains cut off and isolated from all the rest. The actual illustrations of these phenomena are often very interesting and instructive. Thus the *Viviparia unicolor*, which is generally found in Nyasa, and frequents more diversely conditioned parts of the lake than any other form, is replaced in Monkey Bay (a small bay near the southern end of the lake) by a type nearly three times as large, and so far as I know, this variety occurs in no other part of the lake." (Moore, 1903, p. 149, parentheses added).

TABLE 5

Sizes of endemic genera of fishes of Tanganyika and Nyasa

NO. SPECIES/GENUS	TANGANYIKA			NYASA	
	Non-Cichlids	Cichlids	Names of Cichlid Genera	Cichlids	Names of Cichlid Genera
1	5	20		14	
2	3	4		1	
3		5		2	
4		1	*Trematocara*		
5		1	*Bathybates*	1	*Melanochromis*
6		2	*Telmatochromis*, *Limnochromis*		
7					
8				1	*Rhamphochromis*
9					
10					
11				1	*Pseudotropheus*
19		1	*Lamprologus*		
24				1	*Lethrinops*
	11	83	Total no. of Species in Endemic Genera	70	
ENDEMIC CICHLIDS OF NON-ENDEMIC GENERA					
Total no. of endemic species of Cichlids		3 3 — 89	*Haplochromis* (3 monotypic genera)	101 5 — 176	*Haplochromis* *Tilapia*

Our present knowledge is still so scant that it is impossible to affirm or to deny the validity of this example of intralacustrine geographic speciation in the molluscs, but we have a little information about the distribution of the fish within Nyasa. Dr. Cuthbert Christy collected fish from various places at the southern and also at the northern end of the lake. Each of the eight endemic species of *Barbus* was taken at both ends of the lake (Worthington, 1933), but some species of *Haplochromis* and of *Pseudotropheus* appear to be localized. Trewavas (1935) has given the known distribution records of the species of *Haplochromis*, based largely upon the Christy collections. Some data are available concerning the distribution of 84 of the 101 species. Of these, 41 have been found at both ends of the lake, 24 are known only from the southern, and 16 only from the northern end. The northern and southern populations of one species of *Haplochromis* found at both ends of the lake differed sufficiently to be considered subspecies by Miss Trewavas. Two species of *Haplochromis* are listed as occurring in all parts of the lake, but there are no records of the distribution of most species along the eastern and western coasts.

Two species of *Pseudotropheus* have been taken at both ends of the lake. The northern and southern populations of another species (*P. tropheops*) were designated as being subspecifically different. Three other species occurred only in collections at a single end of the lake. One was southern and two were northern. No data on the intralacustrine distribution of *Lethrinops* species are available. It is of considerable importance that the scant knowledge we possess about the distribution of the members of Nyasan flocks indicates that there are intralacustrine geographical subspecies and allopatric species.

Any consideration at the present time of the possibility of geographical speciation within Lake Nyasa must be based upon the cichlid species flocks, since only these have received adequate taxonomic treatment. If intralacustrine geographical isolation is here involved, as the distributional evidence would indicate, there must have been, during the development of the lake, barriers subdividing and isolating once continuous populations for periods sufficiently long to allow genetic divergence. We must examine the modern lake for evidence of intralacustrine geographical barriers effective today. Should any be found, it is possible that their counterparts existed in the past.

Moore (1903) observed that the molluscs and fish, the groups with species flocks, are confined to the shallow littoral zone of sheltered bays and inlets, extending to depths of less than 50 m. Oxygen lack might be the limiting factor. As noted above, during 1937 the oxygen content of the open waters from the surface down to 50 m. was always greater than 6 p.p.m., while below this depth the oxygen content dropped steadily, particularly during the summer (Beauchamp, 1940). Since the water in contact with the mud undoubtedly has a lower oxygen concentration than does the open water, the oxygen tension in the microzone occupied by benthic animals may be too low, below a depth of 50 meters, to support aerobic life. The chironomids, which probably can live at greater depths, are exceptional. The headlands and wave-pounded beaches between the bays appear to be largely uninhabited. Trewavas (1948), however, stated that the rocky shores are inhabited by at least the *Pseudotropheus* group of 9 cichlid genera (with 23 species). Their specialized dentition is presumably employed in removing algae from rock surfaces, although Trewavas did not state this explicitly. These algae-covered rocks probably have a shallow depth range also. The alternation of these different habitats along the shallow habitable strip of lake bottom isolates portions of any population which is restricted to either habitat.

There is at least one section of the shore of Nyasa which, according to Rhoades' map, is so precipitous that the bottom down to below 50 m. not only must be rocky but exceedingly narrow as well. Along the northern half of the west shore, between Nkata Bay and Mrowi to the north, the bottom drops precipitously to over 350 m. for a distance of about 25 km. Similar stretches of steep, but not quite so precipitous shore occur on the northeast coast, to the north and south of Kaiser Bay. It is likely that these portions of the bottom act as barriers to the spread of bay-inhabiting benthic organisms, while the bays are barriers for the rock fishes. This constitutes the most evident type of geographical isolating mechanism effective in Nyasa today.

Moore stated with regard to the mollusca in Nyasa that "great extents of its shore and deep bottom are un-inhabited" (1898, p. 168). The uninhabited shores to which he refers are probably not the precipitous stretch just discussed, but smaller segments of the lake's shoreline. If his observations on the distinctness of the population of *Viviparia unicolor* in Monkey Bay are correct, these smaller segments of uninhabited shore, as well as the rocky shores, are acting to isolate subpopulations of "bay molluscs."

These geographical features would act as barriers only for organisms which are closely tied to a specific type of substratum. The snails which are apparently represented by species flocks are clearly benthic. The habitat requirements of the fish are so diverse that relatively little is known of them. Worthington (1933) constructed a food chain for the non-cichlids, but for the more interesting and more numerous cichlids it has not been possible to do much more than to state, as Worthington did (1933, p. 291), that the cichlids include "phytophagous, insectivorous, molluscivorous, and piscivorous forms." Trewavas (1948) has contributed the only detailed information on food habits. The previously mentioned rockfish are closely associated with a certain substratum, and all species of *Lethrinops* are benthic feeders. The little-studied feeding habits of the hundred species of *Haplochromis* must be very diverse, if one may judge from those of some of the highly divergent monotypic genera. *Chilotilapia* feeds on molluscs. *Aristochromis* is the terminal member of a series of predacious species of *Haplochromis*. Possibly these, and certainly the eight members of *Rhamphochromis* which are open water predators, are not associated with the substratum by their food habits, although they may be by their reproductive behavior. Miss Trewavas has informed me in a personal communication that when native fishermen wish to catch certain species of cichlid plankton feeders they go to various offshore rocks. This may be taken at least as an indication that populations of Nyasan cichlids which are no longer bottom feeders may still be anchored to small portions of the lake.

> The most extraordinary trophic specialization is to be seen in the two species of *Corematodus* (*Haplochromis* except for their file-like dentition) which feed solely upon the small scales on the tails of other cichlids. While *C. toeniatus* has the dark oblique band from nape to caudal fin which is common to many species of this *Haplochromis* species flock, *C. shiranus* bears vertical black bars extending from back to venter. This pattern is strikingly similar to that of females and non-breeding males of *Tilapia squamipinnis*, with which *C. shiranus* associates. *T. squamipinnis* is a plankton feeder which occurs in shoals, and an occasional *Corematodus shiranus* is taken in hauls with numerous *Tilapia*. It is tempting to suppose that *Corematodus* is able to swim unnoticed among the *Tilapia* and feed by nibbling at the small scales at the base of the *Tilapia's* tails. The cichlid scales in the *Corematodus* stomachs unfortunately cannot be specifically identified. No other adequate hypothesis has been advanced to account for this striking resemblance of two unrelated cichlids (Trewavas, 1947b).

Even the fragmentary information on the ecological and intralacustrine distribution of the Nyasan cichlids allows us to see that one species, *Pseudotropeus tropheops*, which is closely associated with rocky bottom, is represented by geographical subspecies. This betokens the presence of isolating mechanisms effective now or in the immediate past. On the basis of our knowledge of speciation in Lake Baikal, the assumption appears justified that geographical factors, whose existence has been pointed out, are involved as the primary isolating mechanism.

However, the cichlid stocks not only in Nyasa but also in Tanganyika and in Victoria Nyanza have speciated to an unparalleled degree, and there can be little doubt that biological factors are acting here to reinforce the initial isolation controlled by intralacustrine geography. Kosswig (1947) has suggested that specialized breeding behavior may be important in restricting genic interchange. Thus any genetic divergence in a population isolated for only a relatively short time might, particularly if the color pattern were altered, lead to inbreeding and more or less complete reproductive isolation even when the geographical barriers are no longer effective. The only flock of Nyasan cichlids which has been studied with reference to this question is that of four species of *Tilapia* so closely similar that they were considered a single species up to 1939. Only one of these has been given a Latin name (*T. karongae*). Trewavas (1947a) referred to the others by their local names, Chambo, Saka, and Lidole. Details of the biology of Chambo and Lidole were given in the 1947 note. Both species are phytoplankton feeders and differences in feeding habits are difficult to detect, although some divergence may exist, as Chambo feeds closer to shore than does Lidole. There are slight differences in dentition, development of pharyngeal bones, and size of mouth. However, the two species are readily distinguishable during their period of breeding. The mature Chambo males are pale blue, while the Lidole males are black. Females and non-breeding males are silver-grey with nearly vertical black bars. Despite the morphological similarity of the females of the two species, their behavior in caring for eggs and young is divergent. Chambo carries the eggs and shelters the young until they have reached a total length of 15 mm., at which time she deposits them in a reed-bed. Lidole continues to shelter her young until they have reached a total length of 40 mm., dispensing with the reed-beds. The mating areas of these two species, whose feeding areas overlap, are separate. Miss R. Lowe, Trewavas' associate, is pursuing field studies of the other two species. Graham (1929) has described the differences in structure and breeding behavior in the two closely similar species of *Tilapia* in Victoria Nyanza.

It may be concluded that at the present time the fauna of Nyasa is subdivided into more or less isolated regions and that the rate of genic flow between them must be slow and may even be completely blocked at one or more places. There is no reason to believe that this same kind of distribution has not been characteristic of Nyasa in the past. The frequently abrupt alterations of the geographical pattern in such a tectonic trough would permit the commingling of long separated neighboring populations and the separation of once continuous populations. The importance of biological factors in the rapid speciation of the cichlida is evident.

The Tanganyika Fauna

The Tanganyika fauna is intermediate between those of Nyasa and Baikal in the diversity of stocks present and the number of species by which many are represented. In the character of its affinities, too, the Tanganyika fauna falls between Baikal and Nyasa. A few of the Tanganyikan stocks belong to groups with wide distributions throughout fresh and brackish waters, but most stocks are characteristic of African freshwaters. A single species has its only known relative living in the East Indian Ocean.

The bulk of the Tanganyikan fauna has been derived from African freshwater stocks which have subsequently undergone more cleavage and divergence than have the Nyasan representatives. This divergence is evident from the many groups which are represented by endemic genera. The molluscs are most remarkable, as 25 of the 44 genera are endemic. As only two of these endemic genera appear to be relicts, the others must have arisen through intralacustrine specialization. The Cichlidae, with about half as many species as in Nyasa, have 34 endemic genera against the 20 in Nyasa. Five of the other families of fish have endemic genera in Tanganyika. Endemic genera are also to be found among the prawns, and possibly the ostracods. Two remarkable water-bugs have been made the types of the genera *Paskia* and *Idiocoris*. These two genera of heterotrephids constitute the subfamily Idiocorinae, which is peculiar to Lake Tanganyika (Esaki and China, 1927).

Many Tanganyikan genera, both endemic and non-endemic, are represented by groups of closely related species. It is our chief concern to ascertain whether these associations arose through intralacustrine cleavage, i.e., are species flocks, and if so, what geographical factors were responsible for isolating the populations within the lake. The principal species associations are found among the fish, molluscs, prawns, ostracods, and copepods. The taxonomy of these faunal groups is reasonably complete. Pilsbry and Bequaert (1927) have revised the molluscs on the basis of all known material, which is still scant. Poll has recently published (1946) a revision of the fishes of Tanganyika. The prawns have been studied by Calman (1906), the copepods by G. O. Sars (1909) and Gurney (1928), and the ostracods by G. O. Sars (1910).

The copepods are well represented in Lake Tanganyika, with 29 species described from two series of collections. Two species (*Ergasilioides*) are parasitic and will not be considered further. One free-living species is a calanoid. There are 18 cyclopoids and 9 harpacticoids. *Tropodiaptomus simplex* (Sars) is not only planktonic, as are most calanoids, but is the principal zooplankter of the lake. Harpacticoids on the other hand are bottom-dwellers, and cyclopoids are known which belong either to the open water or the bottom community. As we might expect, the species flocks, of which there appear to be three, are confined to the bottom-dwelling forms. The eight known members of the harpacticoid genus *Schizopera* (Diosaccidae) of Tanganyika form an indisputable species flock. When Sars described the species, he stated that in his opinion the flock developed in the lake from a single ancestral stock. An equal number of species are known outside of Lake Tanganyika, chiefly in brackish water, although two occur in fresh. Gurney reported that there is at least one other species of *Schizopera* in Tanganyika which he could recognize from its peculiar cast skins but could not describe. Kiefer's classification (1929) of the Cyclopoida, as amended by his subsequent elevation of the subgenera to generic rank, will be utilized in the treatment of this group. All of the Tanganyikan species belong to two subfamilies of the Cyclopidae. Eucyclopinae is represented by four genera, *Paracyclops*, *Ectocyclops*, *Tropocyclops*, and *Eucyclops*, the first two having one and two Tanganyika species, respectively. *Tropocyclops* has but a single species widely disseminated in tropical freshwaters. Seven species are attributed to the fourth genus *Eucyclops*, and four of these are endemic. The seven species of the other subfamily, Cyclopinae, are closely related, being referred to the genus *Microcyclops*. Six of these have not been found elsewhere. Of these two species associations Gurney said: "we find a remarkable wealth of closely-allied forms of the genera *Eucyclops* and *Microcyclops*, which seems to indicate a kind of explosive evolution from a few primary inhabitants" (1928, p. 318, 1. 10–13). Although little is known of the ecology of these copepods, the indications are that these two large groups are bottom-dwellers. It is almost certain, therefore, that one species flock has evolved among the copepods of the Tanganyikan bottom community, and it is probable that there are two others. The reservations which must be borne in mind while considering these two cyclopoid species associations are discussed below.

TABLE 6

Prosobranchiate molluscs of Lake Tanganyika

GENERA	SPECIES PER GENUS	
A. *Tanganyicia* group		
Tanganyicia Crosse	4	
Stanleya Bourguignat	1	
Baizea (*Baizea*) Brgnt	1	
Baizea (*Coulboisia*) Brgnt	3	
Baizea (*Giraudia*) Brgnt	2	
Reymondia Brgnt	3	
Bridouxi Brgnt	1 (?)	
B. *Spekia* group		
Spekia Brgnt	1	
C. *Tiphobia* group		
Tiphobia Smith	1	
Bathanalia Moore	1	
D. *Limnotrochus* group		
Limnotrochus Smith	1	
Chytra Moore	1	
E. *Paramelania* group		
Paramelania (*Paramelania*) Smith	3	
Paramelania (*Bythoceras*) Moore	2	
F. *Lavigeria* group		
Lavigeria Brgnt	8	*
Joubertia Brgnt	3	
Randabelia Brgnt	2	
Hirthia Ancey	2	
Edgaria Brgnt	11	
Lechaptoisia Ancey	1 (?)	
G. *Syrnolopsis* group		
Syrnolopsis Smith	3	
Anceya (*Anceya*) Brgnt	4	
Anceya (*Burtonilla*) Smith	1	
Martelia Dautzenberg	2	

* Should be merged into *Lavigeria* (P. and B., 1927).

The remarkable profusion of 12 endemic species of prawns in Tanganyika is all the more striking by contrast with those two other mighty African lakes, Nyasa and Victoria, each of which has but a single non-endemic species. Calman considered it likely that 11 of the Tanganyika species form one species flock. The odd species belongs to the widely distributed tropical genus *Palaemon*. The 11 members of the species flock have been put into the genera *Limnocardina*, *Caridella*, and *Atyella* having seven, two, and two species, respectively, of the family Atyidae, characteristic of tropical, freshwaters of both the Old and New Worlds.

There are two genera of ostracods in Lake Tanganyika, with large species associations which are almost certainly species flocks. *Paracypria* is represented by 11 endemic species and a twelfth which has been taken also in Lake Albert. This genus may belong to the brackish water element, because the type species was described from the same brackish lagoon on the Chatham Islands as *Schizopera*. Eight species of endemic ostracods from Lake Tanganyika have been assigned to *Cypridopsis*, although they are rather different from other members of the genus, typical representatives of which are found in Nyasa and Victoria Nyanza, one species in each, and these Tanganyikan species should probably be considered to constitute an endemic genus.

Lake Tanganyika not only has many endemic species of molluscs belonging to genera found in Lake Nyasa and elsewhere in Africa, but also has a large number of endemic genera. There are two large endemic genera of pelecypods. *Grandidieria* with 13 species belongs to the Unionidae, and *Pseudopatha* with 5 species pertains to the family Mutelidae. The most remarkable molluscs, however, are the 64 species of prosobranchiate snails, whose relation to other African snails is obscure. Many have come to resemble marine snails in their adaptation to similar habitats and are often referred to as "thalassoid." Table 6 lists the genera to which these thalassoid species are best assigned. Representatives of each group of closely-related genera are shown in Fig. 7. Pilsbry and Bequaert (1927) have expressed the opinion that 17 genera (groups A–F of Table 6) are melaniids. The other three genera (group G) are known only from empty shells and can be tentatively considered a peculiar family, the Syrnolopsidae, possibly related to the Amnicolidae. Possibly all 17 melaniid genera represent one highly diversified species flock.

Although 18 families of fish are represented in Tanganyika, over half of the total number of species belongs to a single family, the Cichlidae

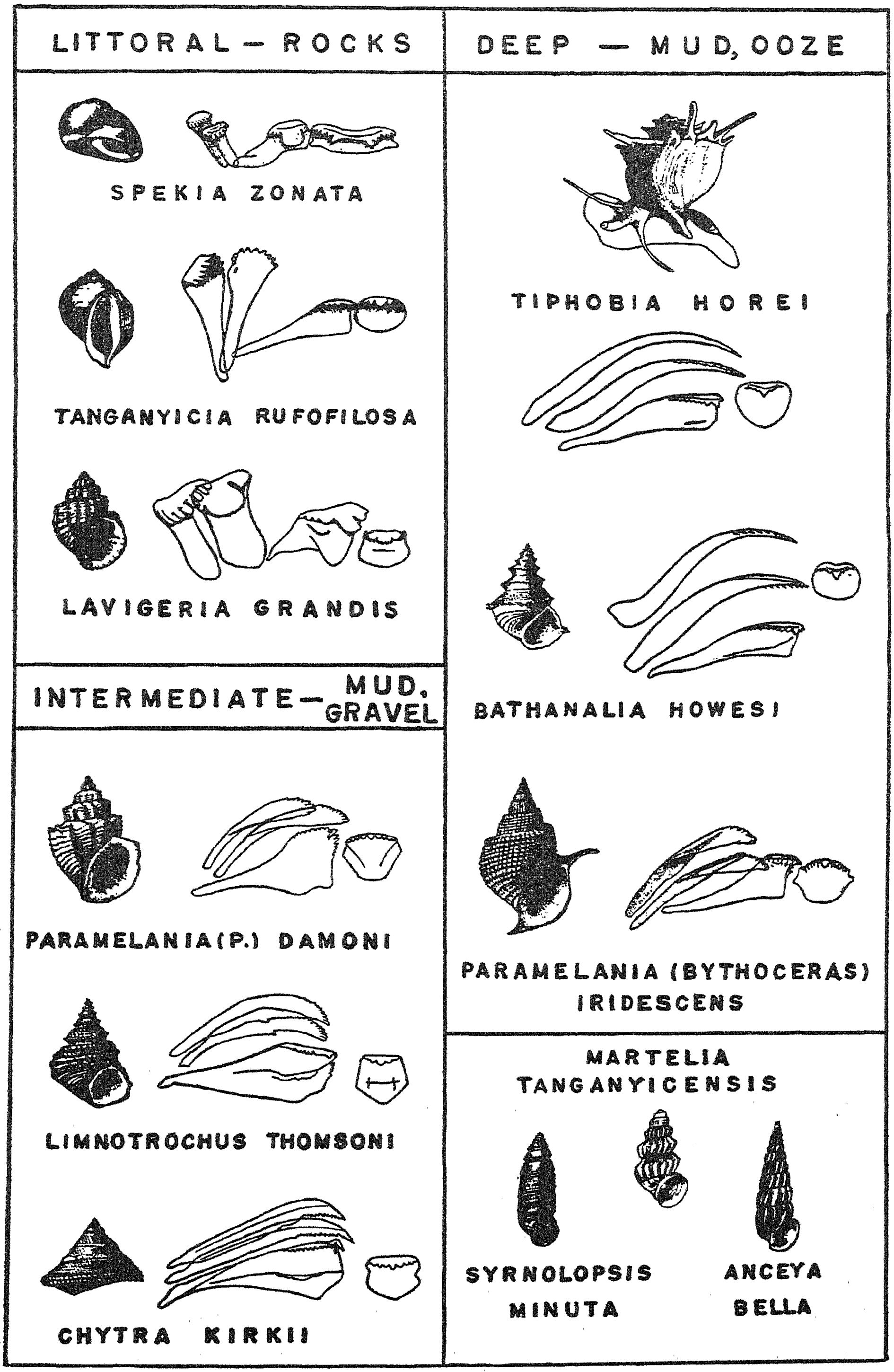

FIG. 7. SHELLS AND RADULAE OF REPRESENTATIVE SPECIES OF TANGANYIKA PROSOBRANCHIATE ("THALASSOID") SNAILS

Spekia zonata, width 13 mm.; *Tanganyicia rufofilosa*, length 11 mm.; *Lavigeria grandis*, length ?; *Tiphobia horei*, length 45 mm.; *Bathanalia howesi*, length (?), ca. 20 mm.; *Paramelania (P.) damoni*, length 32 mm.; *Paramelania (B.) iridescens*, length 110 mm.; *Limnotrochus thomsoni*, length 20 mm.; *Chytra kirkii*, length 10 mm.; *Syrnolopsis minuta*, length 5 mm.; *Martelia tanganyicensis*, length 2.3 mm.; *Anceya bella*, length 10 mm. (The three figures in lower right-hand corner from Pilsbry and Bequaert, 1927; others from Moore, 1903.)

(Table 4). This preponderance of cichlids is not as great as in Nyasa, where it amounts to 80 per cent. Beginning our investigation with this family, we find that there are no genera which approach in size the *Haplochromis* group of Lake Nyasa. *Lamprologus* has 19 species in Lake Tanganyika, and *Telmatochromis*, *Limnochromis*, *Bathybates*, and *Trematocara* have six, six, five, and four species, respectively (Table 5). Poll (1946) has considered that *Lamprologus* and *Telmatochromis* arose from the same stock. This would give the largest cichlid species flock in Tanganyika 25 members. The 23 monotypic endemic genera may contain species which belong to these flocks, but most of them are so highly divergent that determinations of affinity are extremely difficult. *Haplochromis*, which has undergone a tremendous amount of cleavage in Lake Nyasa, has only 5 species in the Tanganyika drainage area, and these are more characteristic of the rivers than of the lake itself. All five endemic species inhabit the rivers, whereas only three of these species have been taken in the lake. *Tilapia*, another non-endemic cichlid genus, is represented by two non-endemic species, probably recent invaders.

Among the other families there are five species associations, each of which may have arisen entirely or in part through cleavage within the lake of a single ancestral stock. Although there are 19 species of the cyprinid *Barbus* in the Tanganyika drainage basin, only six occur in the lake, and only one is restricted to the lake. Four of these six are endemic and may constitute a species flock. The Mastacembelidae, a family of eel-shaped fish, are represented by six endemic and one non-endemic species. (Poll, 1946, listed an eighth species, *M. christyi*, Worthington and Ricardo 1936, as doubtful). The catfish genus *Chrysichthys* of the Bagridae has five endemic species. Another catfish genus, *Synodontis* (Mochocidae), has four endemic and one non-endemic species in Lake Tanganyika. The African centropomids, large predaceous fish, all belong to the genus *Lates*, except for two of the four endemic species in Lake Tanganyika, which are sufficiently different to be placed in the closely allied genus *Luciolates*. The four Tanganyikan species of *Lates* and *Luciolates* probably have evolved in the lake from a single stock. A comparison of the fish faunas of Lakes Tanganyika and Nyasa, employing Tables 4 and 5 and the information of the preceding paragraphs, indicates some of the evolutionary complexities that can be obscured in the statement that 87 per cent of the 223 species of fish in Nyasa are endemic as opposed to 78 per cent of the 162 species in Tanganyika. All of the thirteen families of Lake Nyasa are also present in Lake Tanganyika, and the comparison will be restricted to these thirteen. The cichlids will receive separate treatment. The twelve other families in Lake Nyasa have 45 species, while Lake Tanganyika totals 61 for these same families. Thirty-seven of the 61 in Lake Tanganyika are endemic (61%), while there are 20 endemics in Nyasa (44%). Nineteen of the 37 species endemic to Lake Tanganyika belong to large species associations, of which three (see above) are undoubtedly species flocks. In Lake Nyasa *Mastacembleus* and the Bagridae are each represented by single endemic species, and there is only one non-endemic, *Synodontis*. *Barbus*, with eight endemics, forms the only large Nyasan species association, and this is a doubtful species flock. *Lates* and *Luciolates* comprise the only large species association which does not belong to one of the twelve common families. The endemics of both lakes which are not members of species flocks (the large ones named and possibly a few species pairs in addition) must each represent a population which has become sufficiently modified since its introduction into the lake to receive specific distinction. None of the Nyasan endemics are sufficiently divergent to be placed in endemic genera, but five endemic genera have been created for six Tanganyikan species.

From this comparison of the 12 non-cichlid families common to both lakes, it is clear that not only are there more species flocks in Tanganyika, but also that the Tanganyikan stocks have changed more during their stay in the lake, as is apparent from the greater percentage of endemic species and the presence of endemic genera.

Turning now to the Cichlidae, we find that according to the latest tally (Trewavas, 1948), Nyasa has 178 species, or nearly twice the 91 which have been named from Tanganyika. Ninety-eight per cent of the cichlid species of each lake are endemic. Furthermore, it is evident that most of these endemic species arose through the repeated cleavage of a relatively small number of initial populations. All of the Nyasan endemics have probably developed from between 6 and 10 stocks, one of which has given rise to at least 106 species, by far the largest species flock known in any lake. Estimation of the number of original cichlid stocks in Tanganyika is more difficult. The Tanganyika cichlids exhibit a greater degree of divergence from each other and from populations outside of the lake than do those of Lake Nyasa, making it difficult to determine the relationship between genera. Of the 34 endemic genera, 5 are large, with between 4 and 19 species each, and as a maximum estimate each may be considered a separate species flock. It is highly improbable that the 29 other endemic genera are each derived from a single stock. It is much more likely that these genera, each with between one and three species, represent highly divergent members of a much smaller number of species flocks. It can be assumed that the numbers of initial cichlid populations stocking the two lakes were rouchly the same. If this assumption is correct, there must have been about twice as much cleavage of these initial populations in Lake Nyasa as in Lake Tanganyika. However, the Tanganyikan species exhibit a greater morphological differentiation, as there are 34 endemic genera for 91 species against 20 endemic genera for the 171 species of Lake Nyasa. In this aspect the cichlids resemble the other families. The picture is consistent with the geological evidence, to be considered later, that Lake Tanganyika is older than Lake Nyasa. However, the greater amount of cleavage which has unquestionably occurred in the cichlid stocks of Nyasa must indicate unusually favorable conditions for intralacustrine geographical speciation of that particular element of the fauna.

Worthington (1937), on the basis of his extensive studies of the fish faunas of the African lakes, has suggested that the large predators *Lates* and *Hydrocyon* "have been important factors in controlling the number and variety of Cichlids" (op. cit., p. 310). (The basis for his suggestion will be discussed in connection with Victoria Nyanza.) This is consistent with the findings in Lakes Tanganyika and Nyasa, as both genera are absent from Nyasa, where the amount of speciation has been greater. However, in view of the possible importance of other unstudied factors, it seems advisable to withhold judgment on the relative importance of predation.

Geological history of Tanganyika and origin of its fauna

A summary of the geological and biological evidence relating to the development of the lake and the origin of its fauna, with some mention of the hypotheses which have been elaborated thereupon, is necessary here, since these hypotheses are divergent and often conflicting. This presentation of the geological development of Lake Tanganyika and the surrounding region is based primarily upon material in Willis' monograph of 1936, the latest available summary of East African geology.

Although Lake Tanganyika had its beginning in the latest series of earth movements to affect the topography of East Central Africa, we must extend our investigation farther into the past. Upon doing so it is evident that this plateau region has been above the seas for the greater part of geological time. Highly metamorphosed Pre-Cambrian rock is the foundation rock of the region. The only sedimentary beds, not only in this region but also in the great Congo Basin to the west, are freshwater beds. Over the greater part of what is now British East Africa two peneplains are recognized. The earlier has been dated as Jurassic. From late Palaeozoic to early Jurassic times vast deposits were laid down in the Congo Basin, undoubtedly derived in part from the erosion of the lands to the east. During the Jurassic this peneplained area was uplifted from 300 to 900 meters, and stream erosion had again reduced the topography to a peneplain by the Miocene. Once again the land was elevated, this time by 90 to 150 meters. and before this cycle of erosion, which Willis has named the Malagarasi, had more than achieved maturity in the less resistant rock, the region was convulsed by movements begun in the Pliocene and still in progress.

During the Malagarasi cycle most of the drainage of the area now occupied by Lake Tanganyika was toward the west. One of Lake Tanganyika's major affluents, the Malagarasi River, which drains a large area immediately to the east of the lake, represents one of these old westward flowing rivers which was beheaded by the formation of the lake. There is evidence that at the southern end of Tanganyika a large river, the Chisyera, flowed to the east before the lake was formed. Cameron Bay, the distinct lobe on the west shore at the southern end, is the drowned valley of this antecedent river. The land now covered by the lake was therefore near, if not on, the divide between eastern and western watersheds.

Those crustal disturbances of the Pliocene which gave rise to Lake Tanganyika were vertical displacements that resulted in the formation of a series of troughs which have been called the Eastern and Western Rift Valleys. The Western Rift Valley is shown on the map (Fig. 6). This so-called rift valley is not now, nor was it ever, a continuous trough from one end to the other, as Suess suggested in 1891 before the region had been adequately explored. Rather it is, as Willis was at pains to emphasize, a series of structures aligned along an arc, and the result of both upthrusts and downthrusts. In this western arc there are three downwarps, the Albert, the Edward-George-Kivu and the Tanganyika troughs, named in order from north to south. These downwarped areas are indicated within the interrupted lines on the map. It will be noted that there are three separate highlands situated along this arc, but all are not upwarps. Only Mt. Ruwenzori, the Mountains of the Moon, is an upwarp, an integral part of the crustal deformation which produced the two downwarps immediately to the north and south. The Ruanda Highland, standing farther to the south between the Edward-Kivu and Tanganyika downwarps, antedates the formation of these depressions, being a large mass of resistant rock exposed during the preceding two cycles of stream erosion. The Mufumbiro volcanos arose within the Edward-Kivu trough, which they now subdivide, at a much later date. This last event will be discussed subsequently, as it had important effects on the development of Lake Tanganyika.

The Tanganyika trough, in which our interest centers, is in actuality two troughs en echelon. The Kungwe Peninsula stands at the southern end of the northern trough, and the submerged ridge trending northwest from this peninsula to the headland on the west shore is a strip of the ancient land marking the separation between the two downwarps. Willis established (1936, p. 215) that any areas of the bottom of Lake Tanganyika now standing about 570 meters below the lake's surface are at about the general level before the vertical displacements began. The most recent bathymetric survey has determined that the top of the submerged ridge has an average depth of about 500 meters (data of Copart). This agrees admirably with the deduction that this remnant of the old land surface has been left as a ridge by the sinking of the adjacent troughs. There is no evidence to indicate whether these troughs formed simultaneously, or whether an interval of sufficient duration elapsed between the two events to be of consequence in the evolution of the lake's fauna.

As the troughs began to form, they trapped the water of the rivers which had once flowed across that area. The head waters of westward flowing rivers such as the Malagarasi drained into the troughs, leaving the lower courses of their valleys without their previous supply. Possibly the headwaters of the Chisyera River, which had cut the valley of Cameron Bay, had also been interrupted in their eastward course, swelling the lake beginning in the troughs. Subsequently, due to unequal elevation of the land, its course was reversed so that the modern Chisyera, of meagre proportions, drains westward into Lake Mwero. The deepening troughs retained their water, so that for a large part of its history, undoubtedly the greater part, Tanganyika was at the center of a basin of internal drainage. The inhabitants of the rivers, and the swamps and lakes if there were any, were thus isolated. The majority of the peculiar species of Tanganyika developed from the inhabitants of these freshwaters during that long period of isolation.

It is necessary to emphasize at this point that there is no geological evidence to substantiate the belief that Lake Tanganyika ever had an outlet into the Nile. One of the prime objectives of the Second Tanganyika Expedition, led by J. E. S. Moore, was to ascertain the soundness of Suess' conjecture of such a connection between Lake Tanganyika and the Nile. The expedition found unequivocal evidence that such a northern extension of the lake never existed (Moore, 1903, p. 83). All subsequent investigators have substantiated this. Willis has summarized our knowledge of the Ruanda Highland which constitutes the barrier to the extension of Lake Tanganyika to the north:

> "North of Lake Tanganyika rises the highland of Ruanda, a dome-like elevation, some 300 miles in diameter. Its base in the general level of the plateau may be taken at the contour of 5000 feet (1500 meters). It approaches Lake Tanganyika, Lake Victoria, and Lake George, and extends west beyond Lake Kivu on to the Congo watershed. The area is roughly 120,000 square miles (300,000 sq. km.) and the top of the dome, somewhat north of the central district, reaches 6,500 feet (2000 meters).
>
> "Thus doming up some 500 meters above the rest of the plateau, we might expect this highland to be bounded by faults, but none are known to define it. It is deeply and maturely eroded, in contrast to the typical plateau surface, and yet carries in its summits remnants of an older peneplain, which is correlated with the Jurassic peneplain of the southeastern coast

of Tanganyika. The physiographic observations by Combe have demonstrated that it was already in Miocene times and earlier a relatively elevated region, into which valleys penetrated headward from the Miocene peneplain. It was thus a headwater area in that period and then as now the highest upland in East Africa" (1936, p. 36, lines 14–29).

It is rather surprising, therefore, to find several recent statements to the effect that Lake Tanganyika had, or might have, once drained into the Nile. Robert, in the third edition (1946) of his *Le Congo Physique*, has stated:

> "L'histoire du lac Tanganyika paraît être très compliquée et est loin d'être suffisamment connue. On peut cependant, dès à présent, supposer que les phénomènes y relatifs se sont succédé de la manière suivante. Dans l'ancienne bande en dépression, qui était l'amorce du graben actuel, s'étendait un lac qui avait un écoulement vers le Nord et qui alimentait la vallée du Kivu, ainsi que les lacs Edouard et Albert et enfin le Nil. Le barrage formé par les venues éruptives, au Sud de la zone où est actuellement localisé le lac Kivu, ainsi que les effondrements rélativement récents qui se sont produits localement dans la zone du Tanganyika, ont modifié cet ancien état de choses et fait du Tanganyika un lac sans écoulement" (p. 200, lines 31–41).

This statement, for which no authority is given, must be considered erroneous. Poll (1946), when writing of the fish fauna of Lake Tanganyika, used the second edition of Robert's book as a source for the geological history of the lake and was misled into a belief that the peculiar fish fauna of the lake was of Nilotic origin. However, as Worthington (1936) has pointed out, the origin of the fish fauna of Lake Tanganyika was in the piscine stocks of the African rivers of Pliocene times. A large part was undoubtedly derived from westward flowing rivers, accounting for many of the similarities of the endemic species to stocks now living in the Congo basin. The cyprinid *Labeo weeksii* is found within the Tanganyika drainage basin only in the headwaters of the tributaries of the Malagarasi River System, although it is widely distributed throughout the Congo basin. Although Poll (1946) found this distribution unexpected, it is to be expected if the Malagarasi once drained directly into the Congo, as there is reason to believe it did. *Barbus eutaenia*, similarly restricted to the upper parts of the Malagarasi System within the Tanganyika drainage area, occurs in the Katanga region of the Congo watershed, Angola, Transvaal, and Lake Nyasa. This species, too, probably inhabited the Malagarasi before Lake Tanganyika was formed.

Fuchs (1936) discovered in the Kaiso beds (early Pleistocene) bordering Lakes Albert and Edward fossil molluscs similar to some stocks now living in Lake Tanganyika. He placed a viviparid snail in the genus *Neothauma*, which at present occurs only in Tanganyika. However, the form which lived in Lakes Albert and Edward is specifically distinct (*N. dubium*) from the extant *N. tanganyicense*. Two species of fossil unionids resemble *Grandidieria* of Lake Tanganyika, but in the absence of the soft parts necessary for proper generic differentiation Fuchs has wisely retained the older and more inclusive name *Unio*. On the basis of these palaentological discoveries, Worthington and Ricardo concluded:

> "In the first place, it is postulated that at some early period Lake Tanganyika was much more extensive than now, particularly towards the north, and was probably in communication with the lakes and rivers in the northern part of the Rift valley, including the Nile. Evidence for a northward extension of Lake Tanganyika is brought forward by Fuchs (in press), who shows that fossil molluscs from the Kaiso beds, of the Middle Pleistocene period, near Lake Edward, are closely related to the present forms living in Lake Tanganyika, and differ markedly from any known to exist in Lake Edward today." (1936, p. 1070, lines 32–39).

As such a northward extension is excluded geologically, the explanation of the presence of these fossil molluscs is undoubtedly that suggested by Fuchs himself, namely, that these genera represent a molluscan fauna which enjoyed a wide distribution over that region of central East Africa during Wayland's first Pluvial period. During the excessive aridity of the first Pleistocene interpluvial period (cf. Wayland, 1934) these forms became extinct as all of the permanent habitable waters of the region disappeared. Fuchs' discovery of the remains of crocodiles and *Lates*, the Nile perch, in the Kaiso beds of Lake Edward, where neither of these forms live at present, provided further evidence of the desiccation of Lake Edward with the extinction of its archaic fauna. *Neothauma* and *Grandidieria* were able to survive only in Lake Tanganyika, which never dried up because of its great depth. Subsequently Fuchs (1939) studied the fossil molluscs of the Gaza Beds in the Lake Rudolf basin. The recent molluscan fauna of Rudolf, like that of Lakes Albert and Edward, is essentially nilotic. Three species characteristic of the Kaiso Beds of Uganda occurred together in all the Gaza samples. These are *Viviparus unicolor*, *Cleopatra ferruginea*, and *Unio* (*Grandidieria*) *abruptus*. None of these is found in any later deposits. The Gaza Beds were presumably laid down during the first pluvial, like the Kaiso. Connelly (cited in Dixie, 1927) found the first species, i.e., the snails, in the Chiwando (middle Pleistocene) beds of Lake Nyasa, which is not surprising in the light of their present wide distribution in Africa. More important is the absence of *Neothauma* and *Grandidieria*.

Lake Tanganyika remained isolated within its basin of internal drainage for a period whose duration cannot be accurately estimated. The lake had its inception sometime during the Pliocene, which lasted about 13 million years according to the best evidence available (Zeuner, 1946). Even if this event occurred in late Pliocene, the lake would have been at least one to two million years old at the end of this epoch. The events which led to the termination of this phase of the lake's history took place during the middle of the late Pleistocene, an epoch which lasted about one million years. A minimum estimate of the duration of the isolation of Lake Tanganyika would therefore be one and one-half million years, while a reasonable maximum would be six million.

The events leading to Lake Tanganyika's acquisition of an outlet began many miles to the north. The eruption of a chain of volcanos across the Edward-Kivu downwarp blocked the northward escape of water from the northern slopes of the Ruanda Highlands. These impounded waters formed Lake Kivu in the drowned head-end of the valley which had previously drained into Lake Edward. Lake Kivu grew until it topped the lowest point in the highlands surrounding it. This low point was on the south rim, so that the overflowing waters drained into Lake Tanganyika. The inflow to Tanganyika now exceeded evaporation and its level rose until it reached a low point in its rim. This low point appears to have been an old westward running valley of the Malagarasi cycle of erosion, which had been beheaded by the sinking of the Tanganyika troughs. Once again water flowed westward in this valley down into the Congo Basin as Lake Tanganyika gained an outlet, the Lukuga River, and lost that isolation during which its fauna had evolved along peculiar lines. Moore, leading the Second Tanganyika Expedition, was the first to read this story from the geography north of Tanganyika.

The formation of the Mufumbiro chain of nine volcanos, which had such far-reaching effects upon the drainage pattern of Central Africa, was not a single event but appears to have extended over the greater part of the Pleistocene. The volcanos occur in three groups of three. The eastern and central groups comprise craters no longer active and eroded to such an extent that their formation has been referred to the early Pleistocene (Willis, 1936, based on the studies of Coombe). The volcanos of the western group are now active and probably are of later origin than the other two groups, although more precise dating has not been possible. This western group is so situated that it appears to be the one responsible for the damming of the river of the Kivu valley. As Lake Kivu, therefore, had its origin during the middle or late Pleistocene, its final consequence, the formation of the Lukuga River, occurred after the lapse of an unestimated interval.

These recent hydrographic changes involving Tanganyika are reflected by the distribution of some of the non-endemic species of Tanganyika fish. Species which have been introduced into Tanganyika from Kivu constitute but a minor fraction and are easily differentiated. However, the acquisition of a recent connection with the Congo Basin, via the Lukuga River, with the attendant possibilities of faunal interchange, renders difficult the interpretation of the origin and affinities of many endemic species.

There are only two species of fish found in the Tanganyika basin as well as in Lakes Kivu and Edward (Poll, 1946). These two species are closely related, *Barbus serrifer* Blgr. and *B. pellegrini* Poll. Both fish are associated with the affluents within the Tanganyika basin; indeed, *B. pellegrini* is never found in the lake, living only in the upper reaches of the Malagarasi River. *B. serrifer* inhabits all the other tributaries and has only been taken in the lake itself close to the mouths of these affluents. In the Kivu and Edward basins also, these fish exhibit a preference for the tributaries rather than the lakes themselves. It is not surprising then that, when the headwaters of a large tributary of Lake Edward were cut off from the lower reaches of the system, only the rheophil species of the basin would be present to stock the new Lake Kivu. As few fish (two, from Poll's data) have been able to ascend the torrential

Ruzizi from Tanganyika to supplement these stocks, the poverty of the Kivu fauna is understandable. *B. serrifer* has been found in two rivers of the Congo Basin, the Uele and the Ituri (Poll, 1946), whose headwaters are in the highlands to the west of Lakes Albert and Edward. Its restriction to these two rivers of the Congo System makes it likely that *B. serrifer* gained entry into these Congo tributaries by stream capture involving their headwaters and those of tributaries of Lake Edward.

There have been three possibilities for interchange between Lake Tanganyika and the rest of the Congo System by which the manifest similarities between their fish faunas might have arisen:

1. Species inhabiting the Congo System during Pliocene times might have been trapped in the newly-formed basin of internal drainage centering about Lake Tanganyika.
2. Species might have migrated into the lake through the recently formed Lukuga connection.
3. Species might have spread from Lake Tanganyika into the Congo System through the Lukuga.

Any stocks introduced into Lake Tanganyika at its formation (1), would in all probability have evolved sufficiently during the period of isolation in adaptation to lacustrine conditions to be no longer conspecific with the descendants of these stocks in the Congo Basin. The affinities of some of the endemic species are not clear, but others show an evident relation to the stocks still living in the Congo Basin. An example is the predaceous centropomid *Lates*. *Lates nilotica* is widespread throughout the Nile and Congo Systems. This species does not occur in Tanganyika, although four obviously related species do. Two of these are sufficiently like *L. nilotica* to be retained in the same genus, but the other two have been separated into the endemid genus *Luciolates*. If *Labeo weeksii* and *Barbus eutaenia* (cf. p. 147), which inhabit the headwater streams of the Tanganyika drainage basin, colonized these headwaters before the lake formed, as is likely, then these populations have been isolated from the nonspecific ones in the headwaters of the Congo basin proper for as long a time as those other species from which the peculiar lacustrine forms have developed. That they have not diverged noticeably can only be attributed to the constancy of their environment.

Although some of the non-endemic species of Tanganyika fish may have survived the period of isolation without specific divergences, many, particularly those which also live in rivers, have undoubtedly invaded the lake since the recent formation of the Lukuga River connection (2). It seems likely, for example, that the only two non-endemic cichlids of Tanganyika, *Tilapia nilotica* and *Tilapia melanopleura*, are recent invaders. Both have very large areas of distribution and are as much at home in rivers as in lakes. Worthington (1936) believes that the Kakoma Rapids of the Lukuga may constitute a barrier to the spread of many species from the Congo Basin into Tanganyika. In all, 33 of the 48 non-endemic fish of Tanganyika occur now in the Congo Basin.

One clear case of the recent spread of a fish from Lake Tanganyika to the rest of the Congo System (3), according to Poll, 1946, is that of the cichlid genus *Lamprologus*. *Lamprologus* is represented in Tanganyika by 19 species. Poll (1939) has listed only three other species from the rest of the Congo System, two without description, although he had expressed the opinion in 1933 that there were probably only two valid species. The numerical dominance in Tanganyika, together with the presence there of species of *Telmatochromis* which Poll has considered very like the stock from which *Lamprologus* differentiated, led him to the conclusion that the latter genus has evolved in the lake. One of the 19 present-day Tanganyika species, *L. stappersi* Poll, can maintain itself in rivers, and from some such stock the two or three species in the lower parts of the system have apparently developed.

The last hydrographic connection to be considered is that between Tanganyika and Rukwa, a small lake lying in its own downwarp (see map) about 190 km. (80 mi.) east of the southern end of the larger lake. The connection, if it ever existed, was undoubtedly through a valley or depression running between the two troughs, called the Karema Gap. However, within this valley there is a rise to about the highest lake level discovered in the Rukwa trough, viz., some 200 meters above the surface of the present lake. Many geologists in the past and as late as 1936 (de la Vallée Poussin) have considered the geological evidence favorable to the hypothesis of a connection; but Teale (1930, quoted in Willis, 1936) believed the field evidence to be inconclusive. On the other hand, Stockley (1939) was firmly convinced that there never was any direct hydrographic connection between the two lakes. The most convincing support for the hypothesis of a direct connection comes from the discovery of numerous fossil snail shells in the now dry lake beds north of the present Lake Rukwa. These shells pertain to the thalassoid genus *Edgaria* of Tanganyika, (Cox, 1939). If Stockley were correct, it is exceedingly difficult to imagine any way in which *Edgaria*, which is restricted to rocky, sheltered shores in Lake Tanganyika, could have gained entrance into Rukwa. On the other hand, if there had been a connection, it is odd that only one genus of thalassoid snails should be found in Rukwa, and not more.

The present molluscan fauna bears no relation to that of the fossil beds. This is taken as evidence that Lake Rukwa, which is never more than 5–6 meters deep at present and which dries up in part during the rainless season, must have dried up completely subsequent to the deposition of the extensive fossiliferous beds. Possibly this occurred during the first major interpluvial, coinciding with the desiccation of the shallow lakes to the north, i.e., Lakes Edward, Albert, Victoria, and Rudolf.

Ricardo (1939) reported that three species of fish are common to Tanganyika and Rukwa. Two of these are cyprinids, *Barilius moorei* and *Engraulicypris congicus rukwaensis*, and the third is the catfish *Clarias hilgendorpi*. Poll (1946) was doubtful of the validity of this latter species, and it cannot be used in the present discussion. *Barilius moorei*, as noted above, also occurs in Kivu, and *Engraulicypris* occurs elsewhere in the Congo System. Ricardo, considering that the two cyprinids are typical of the open waters of Tanganyika, believed that their presence in Rukwa supports the hypothesis that an open water connection existed between the two lakes at some time in the past. Any fish which had entered Rukwa from Tanganyika through the supposed connection would not have been able to survive the period of desiccation which the molluscan evidence requires. However, *Barilius moorei* has been taken in streams and brooks tributary to Lake Tanganyika (Poll, 1946), and has been able to reach Lake Kivu by ascending the Ruzizi. *Engraulicypris congicus* is equally at home in rivers. Since *E. congicus* has not been reported from Lake Bangweulu, it is unlikely that it entered Lake Rukwa from the Chambezi (Ricardo-Bertram, 1943). Introduction of these fish into Rukwa through capture of the headwaters of tributaries of Lake Tanganyika by those of Lake Rukwa, or through swamps draining into both watersheds, is most probable.

The geological history of central Africa aids in elucidating the origin only of some of the piscine and a few molluscan stocks. The origins of other stocks remain obscure, for many undoubtedly go back to the time of the lake's formation. The thalassoid snails presumably are derived from fluviatile ancestors which were present at the lake's genesis, but these descendants have so far given no clue to the relationships of their ancestors. Other groups of molluscs may have invaded at later periods (Pilsbry and Bequaert, 1927). The prawns clearly belong to a family which has long inhabited tropical rivers and ponds. Their presence in Lake Tanganyika, like that of the fish and molluscs, is comprehensible even though detailed information be wanting.

There are several groups in Tanganyika whose close relatives have such remarkable distributions outside of the lake that their very presence in the lake is perplexing. The harpacticoid copepod genus *Schizopera* occurs in coastal brackish waters around the world (Egypt, Chatham Islands, Hawaii, Haiti, Caspian Sea). Freshwater species have been found in Toba Lake, Sumatra, and in the subterranean waters of southern Italy. The gymnolaematous bryozoan *Victorella* occurs not only in the coastal brackish waters of Europe and Asia but in some of the basins in the interior of Asia as well. Furthermore, a marine species was discovered by Harmer (1915) in the East Indian Ocean. The marine affinity of the other of the two Tanganyikan gymnolaematous bryozoans, *Arachnoidea raylankesteri*, is even more evident, because the only other species which has been assigned to this genus was found in the Straits of Makassar in the East Indian Ocean.

As in the consideration of the origin of the Baikalian fauna, several interpretations of these patterns of distribution are possible. Tanganyika might once have been an arm of the sea, or it might have been connected with a basin which once had been a part of the sea, and subsequently have been freshened. According to either of these possibilities Tanganyika is considered to have had a special link with the sea, and the fauna so derived would have no close relation to the faunas of the other freshwaters, unless they had spread from Tanganyika. Opposed to this is the interpretation of this special element in Tanganyika as the relict of an archaic fauna which has been supplanted in most freshwaters.

Early knowledge of the peculiarities of the Tanganyikan fauna, in particular the "thalassoid" appearance of snail shells collected by Speke, and Böhm's discovery of the trachyline medusa *Limnocnida tanganicae*, suggested a marine origin for this lake. Moore espoused this hypothesis and in a series of papers presented what appeared to be biological evidence that Lake Tanganyika arose as an arm of the Jurassic sea. As knowledge of the faunas of Tanganyika and the other lakes and rivers of Central Africa increased, Moore's biological evidence lost its cogency and the accumulating geological information made it quite clear that the sea had never reached the site of Lake Tanganyika. Cunnington (1920) ably mustered all of the pertinent information to prove that the hypothesis as presented by Moore was untenable.

However, the discovery of the marine species of the bryozoan *Arachnoidea*, made subsequent to Moore's latest presentation of his hypothesis, and the gradual accumulation of information about the distribution of such forms as *Schizopera* and *Victorella* bolsters the appearance of affinity between Tanganyika and the sea. In attempting an explanation of this apparent affinity it is necessary to give serious consideration to the possibility that Tanganyika gained some or all of this special element of its fauna from a modified marine basin. This would parallel Vereščagin's hypothesis of the origin of the "marine" element of Lake Baikal. The hypothetical basin could not have been to the west of the present lake, as no marine deposits are known in the Congo Basin. Evidence already considered proves that the connection could not have been to the north, i.e., to the Nile Basin. The nearest marine transgression to the lake was on the east, indicated by the Jurassic, Cretaceous, and early Tertiary marine strata of the eastern part of Tanganyika Territory. Although the westernmost position of the sea coast is uncertain, due to the erosion of the marine beds, it may possibly have reached the edge of the central plateau during the Cretaceous, as indicated on the map. (Information from Willis' account (1936) of the geological history of Tanganyika Territory). Therefore, any such basin must have been east of the site of Lake Tanganyika near the western limit of transgression. Crustal movements were common at the time of these transgressions and there is a possibility that a small basin might have become landlocked. The Ruaha River system which drains that area of the plateau immediately to the east of the Tanganyika drainage basin has maintained itself since pre-Cretaceous times. The modified marine fauna would then have been carried as far west as Tanganyika via ponds and lakes formed along its course by crustal deformations. At present part of the Ruaha trough (see map) is drained into the Ruaha system, while the western end drains into Lake Rukwa. Lacustrine deposits cover the bottom of the Ruaha trough and suggest that a possible route was through these ponds or lakes to Rukwa and then to Tanganyika.

There is no evidence to indicate which of the three marine transgressions was involved, although that of the Cretaceous extended nearest to Tanganyika. If the postulated basin was originally a part of the Cretaceous sea, then the time interval before the formation of Lake Tanganyika is reasonably adequate.

The known facts of the distribution of close relatives of the special element of the Tanganyikan fauna lend themselves less readily to their interpretation as the relics of an archaic fauna of continental waters than do those for the similar element in Lake Baikal.

Distribution and speciation within Lake Tanganyika

With this synopsis of the animals which appear to have speciated within the lake and the origin of their ancestral populations now behind us, we can proceed to an examination of their distribution for evidence of intralacustrine geographical speciation. The available information concerning spatial distribution of the members of these flocks is poorer than for Lake Nyasa. The collections of prawns and copepods have been too limited to provide any concept of their distribution. Although Poll (1946) has compiled much information on the distribution of the fish species within Lake Tanganyika, this cannot substitute for a field investigation of distribution. It is most regrettable that Christy's field notes, giving the localities of his large collection of Tanganyika fishes, were lost after his death (Worthington and Ricardo, 1936). Unless they are found there is little hope of learning more about the distribution of the endemic species of fish in the near future.

The largest collections of molluscs have been made by the expeditions led by Moore, 1895–1899,

TABLE 7

The distribution of thalassoid snails in Lake Tanganyika

(Based on table in Dartevelle and Schwetz, 1948)

SPECIES	NO. SPECIES (Stappers)	HORIZONTAL DISTRIBUTION (WEST COAST)	VERTICAL DISTRIBUTION (Moore and Cunnington)	VERTICAL DISTRIBUTION (Stappers)
Rocky Littoral				
Spekia zonata	689	N–S	0–30 M.	0–70 (chiefly at shallow depths)
Tanganyicia rufofilosa	3005	N–S		0–70
Tanganyicia soluta	2	N		
Stanleya neritinoides	1001	N, C		3–33 (chiefly at 35 M.)
Giraudia tanganyicensis	15	S		20 (1 species)
Giraudia horei	184	C, S	16.5	7–55 (chiefly at 20 M.)
Giraudia minor	137	C, S		0–35
Lavigeria grandis	298	C, S	0–30	0–70
Hirthia littorina	2	S		
Hirthia globosa	6	C, S		
Edgaria arenarum	18	S		76 (1 species)
Edgaria crassilabris	95	C, S		15–76
Edgaria egregia	2	S		
Edgaria formosa	3	S		
Edgaria giraudi	2031	N–S		0–45 (few species)
Edgaria lechaptoisi	3	S		
Edgaria nassa	2029	N–S		0–100
Edgaria n. livingstoniana	295	C, S		0–70
Edgaria milne-edwardi	2	S		
Edgaria paucicostata	1015	N–S		0–110
Edgaria singularis	106	C, S		0–45 (2 species)
Intermediate				
Paramelania (P.) damoni	109	N–S	41–65	3–100 (chiefly below 20)
Paramelania (P.) crassigranulata	13	N–S		1–35 (few species)
Limnotrochus thomsoni	173	N–S	16–125	0–70
Chytra kirkii	193	N–S	33	9–150
Deep				
Tiphobia horei	42	N–S	76–300	76–100
Bathanalia howesi	1	S	126–300	76
Paramelania (B.) iridescens	69	N–S		0–125
Syrnolopsis m. minuta	539	C, S		8–35
Syrnolopsis m. carinata	23	C, S		0–100
Syrnolopsis l. lacustris	166	C, S		8.5–20
Syrnolopsis l. molirensis	29	S		3–70
Syrnolopsis l. pluricarinata	25	S		8.5–20
Syrnolopsis l. lilacina	70	Extreme S		0–90
Syrnolopsis gracilis	19	N–S		35–90 (few species)
Anceya giraudi	960	C, S		5–130
Anceya admirabilis	99	S		76–90
Anceya bella	17	C, S		35 (2 species)
Anceya rufocincta	29	S		76 (2 species)

Cunnington, 1904, and Stappers, 1910–1912. Stappers' collection, the most extensive, was not reported until 1948 (Dartevelle and Schwetz, 1948). Although Pilsbry and Bequaert had only a part of the Stappers' material at their disposal in 1927, their system has proven adequate in classifying the bulk of the collection (Table 6). There has never been a systematic endeavor to study the intralacustrine distribution of the molluscs. Only scant knowledge is to be gained by an analysis of the records of the various collections. Stappers' collection, the most useful, yields less pertinent information than might be hoped, because this expedition explored only the west coast. Furthermore, the localities are recorded by Dartevelle and Schwetz only as north, central, or south. Although they concluded that there is no evidence of geographical distribution within the lake, their data (Table 7) support a different interpretation.

Before proceeding with the analysis of the horizontal distribution it is necessary to consider the vertical distribution and ecological preference of the various snails. Stappers' collection is not very helpful in these considerations because of two sorts of omissions from the field records. No indication is given as to whether a specimen was alive or merely a shell when collected. The limits of the vertical distribution may therefore be in considerable error. The second omission is that of any record of the substratum on which a specimen was taken. All the ecological information which was available in 1927 has been analysed and summarized by Pilsbry and Bequaert. This is accepted without alteration by Dartevelle and Schwetz (1948).

The broad aspects of the ecology of the Tanganyika molluscs can be sketched. The molluscs of non-endemic genera abound in the bays and swamps around the lake, just as the Nyasan species of the same genera do. The endemic bivalves, *Grandidieria* and *Pseudospatha*, are now restricted to depths of less than 25–50 m. according to Pilsbry and Bequaert (1927), although Moore in 1898 recorded *Grandidieria burtoni* from much greater depths. (The significance of depth records at different times is discussed in detail below in connection with the thalassoid snails.) The prosobranchiate snails of Tanganyika live in habitats apparently unexploited by any Nyasan snails, although the same habitats surely exist in the latter lake, too. The habitats are of three types, rocks on the surf-pounded stretches of shore, mud and gravel bottom at intermediate depths, and mud bottom at the greatest habitable depths. In Fig. 7 the taxonomic groups occupying each habitat are shown, together with their radulae.

The large genus *Edgaria* is exceptional. Its members live on rocks sheltered from strong wave action. The habitats of syrnolopsids are unknown. Yonge has recently (1938) called attention to the differences in the radular structure in the three ecological groups. The stout-toothed radulae of *Spekia*, *Tanganyicia*, and *Lavigeria* are apparently used to scrape algae from rocks. Moore (1899) found that the radular sac of *Tanganyicia rufofilosa* is very small relative to the size of the snail, and made the further observation that on dissection "the mouth, oesophagus, stomach, and rectum were crammed with sharp rock fragments, about the size of a pin's head; and it is a curious fact that these animals should thus exhibit a propensity to fill themselves with stones, while at the same time the radula, or normal rasping apparatus, is almost entirely lost" (op. cit., p. 157). The radulae of *Tiphobia* and *Bathanalia* have long marginal teeth much like those of *Aporrhais*, which is known to pick up detritus of vegetable origin from the mud. Moore stressed the resemblance of the radula of *Chytra* to that of *Capulus* which, as Yonge has stated, "is now known to act merely as a conveyor into the oesophagus of mucus-laden masses collected by the enlarged ctenidium" (Yonge, 1938, p. 465). The possession of a crystalline style by all of these prosobranchiate snails characterizes herbivorous molluscs, as indeed the majority of other freshwater prosobranchiates have proved to be (Yonge, 1938).

By comparison with Lake Baikal the littoral habitats are likely to be geographically discontinuous, while the deep one is almost certainly less discontinuous, if not continuous. The alteration of bays and headlands is an alternation of at least two types of littoral habitats. The bays of Lake Tanganyika are largely populated by species of non-endemic genera, closely resembling those of Lake Nyasa in this respect. These bays isolate the headlands where rocks exposed to and sheltered from wave action provide different habitats.

In addition to the geographical pattern there are considerable [line 1] variations in the productivity of different parts [line 2] of the lake. Beauchamp (1939) found that the surface layers of the open waters of Tanganyika were unproductive, probably due to their low nitrate content. As a result, the greatest development of the biota occurs where rivers with a nutrient salt content higher than that of the surface lake water empty into shallow parts of the lake. Here littoral vegetation flourishes and the rocks are covered with algae. The shallow ends of the lake are very productive, as are these local regions mentioned above, but elsewhere the biota is sparse.

The available data on the horizontal distribution of the thalassoid snails indicate that species living in littoral habitats are more localized in that distribution than are those living at greater depths (Tables 7 and 8). Only one-third of the 21 littoral species taken by Stappers were not restricted to portions of the west coast. All four species living at intermediate depths occur in all the basins. Two of the three species inhabiting the deep zone have a similarly wide distribution. *Bathanalia howesi,* however, is exceptional, having been taken only in the southern basin. This localization is probably real even though the species has been rarely taken. This relationship between horizontal and vertical distribution, although based upon scant information, is consistent with the findings in Lake Baikal.

TABLE 8

Summary of distributions of thalassoid snails in Lake Tanganyika

RANGE OF DISTRIBUTION	SYRNOLOPSIDS	MELANIIDS			TOTAL
		ROCKY-LITTORAL	INTERMEDIATE	DEEP	
N–S	1	5	4	2	12
N, C	—	1	—	—	1
N	—	1	—	—	1
C	—	—	—	—	0
C, S	5	7	—	—	12
S	5	7	—	1	13

Another aspect of the horizontal distribution which is apparent from Table 8 is worthy of further mention. Although the three divisions of Dartevelle and Schwetz appear to be to roughly equivalent lengths of coastline, the southern division has 13 species and subspecies restricted to it, the northern has one, and the central has none. Furthermore, twelve of the fourteen forms taken in the northern division occur in the other divisions as well, while two-thirds of all the forms have never been taken at the northern end of the lake. The significance of these regional differences is not apparent.

The ranges in vertical distribution which Moore and Cunnington reported from collections made between 1895–1904 fall within those recorded by Stappers for 1910–1912, with the exception of three species (Table 7). *Limmotrochus thomsoni*, *Tiphobia horei*, and *Bathanalia howesi* were found by Stappers in much shallower water than the previous collectors had found them in. Since the last-named species was taken but once, this finding is of less significance than those pertaining to the other two species, which were well represented in the Stappers collection. This surprising difference in the range of vertical distribution of these snails becomes astonishing when supplemented by the observation of Beauchamp that *Tiphobia horei* was living at the surface of Lake Tanganyika in 1937, and extended down as far as the thermocline, i.e., 60 to 80 m.

And now, since there is no evidence to the contrary, it is assumed that these snails require oxygen and that the lower limit of their distribution will be the depth at which the oxygen concentration in the water in contact with the bottom is nil. In 1937 the open waters, in the summer, contained oxygen down to 60 m. depth during the period of stratification. Beauchamp (1939) reported that at the time of his hydrological observations *Tiphobia horei* was abundant just above the thermocline and could even be found at the surface. At a depth of 80 m. the superficial layer of mud changes from an oxidized to a reduced state (Beauchamp, 1946), and judging from the work of Mortimer (1941), the oxygen content at the mud surface at this depth is probably between 0.5 and 0.1 mg./1. Certainly molluscs cannot live at oxygen tensions lower than this.

The inescapable conclusion from these records is that the depth to which Tanganyika waters have been oxygenated has varied within the last century. To mix oxygen to a depth of 300 m., as apparently occurred in 1895, the epilimnion either must have extended to that depth, or have been somewhat deeper than it is today, and must have had oxygenated water turbulently mixed through the thermocline to a depth of at least 300 m. In Lake Nyasa turbulence in the upper part of the hypolimnion carries oxygen to a depth of 200 m. during summer stratification.

The vertical extent of bottom available for the deep-water species has a considerable effect upon the relations between these and the second ecological group of molluscs, which might be called the "bay" group. Moore reported in 1898 that the bay group occurred down as far as 50–80 m., while the deep-water forms were living well below this depth. Their areas of distribution overlapped little. In 1937 Beauchamp found *Tiphobia horei*, which Moore had characterized as a deep-water form, living at the surface and down to depths of about 60 m. Its present vertical range is that which the species of the bay group occupied fifty years ago. The effect which this intrusion has had upon the two groups is not known.

It is of great biological importance to know how deep the waters of Tanganyika have been mixed in recent geological times. If the mixing extended to 300 meters fifty years ago, how deep was it mixed two centuries ago? Since prolonged stagnation should lead to gradual settling of heavy isotopes, it ought to be possible, by making a study of the isotopic composition of the hydrogen and oxygen of a vertical series of water samples, to ascertain the maximum depth to which mixing has extended.

The influence of one other geographical feature on intralacustrine speciation remains for discussion. This is the submerged ridge, a continuation of the Kungwe Peninsula which separates the two large basins of Lake Tanganyika. Since the top of the ridge is about 500 m. below the present surface, it can be of no importance as a barrier at the present time, because the biota does not extend that deep. It seems unlikely that at the present lake level the biota ever extended as deep as 500 m. However, at more remote times, during the dry periods of the African Pleistocene, the lake level may well have been low enough for the ridge to be effective in isolating part of the fauna into northern and southern portions. This would have had a profound effect upon intralacustrine speciation, as we have seen a similar ridge may have done in Lake Baikal. It will be recalled in this connection that two-thirds of the species of thalassoid snails are restricted to the southern and central parts of the west coast of Lake Tanganyika.

Multiple invasions

Although we have seen that intralacustrine speciation of a cleavage type has probably been responsible for the formation of species of prawns, three groups of copepods, the majority of the molluscs of Lake Tanganyika, and many groups of fish in both Tanganyika and Nyasa, it is necessary to consider the possible role of multiple invasions in the formation of other types of species associations. Although it is not possible to accept Mayr's suggestion (1942) of multiple invasions as the origin of species flocks, (a conclusion also reached by Trewavas, 1948, for Nyasan cichlids) at least one of the mechanisms of multiple invasion which he proposed has almost certainly been responsible for the presence within a lake of several species of a given genus. The distinction between this latter type of species association and a species flock is that the members of a species flock of a lake are all more closely related to one another than to any population existing outside of the lake.

A tabulation (Table 9) of all non-cichlid associations in Lakes Tanganyika and Nyasa of two or more species of fish containing at least one species widely distributed outside of the lake elucidates a difference in the composition of the associations of the two lakes.

The composition of the Tanganyikan associations is such that the factors involved in their formation can be assigned with fair probability. In the large groups *Barbus*, *Synodontis*, and *Mastacembelus* it is highly probable that the endemics arose through intralacustrine cleavage of stocks introduced into the lake early in its history. The one or two non-endemic species in each genus have undoubtedly been introduced at a relatively recent date. On the other hand, associations composed entirely of non-endemic species, such as those of *Clarias* and *Marcusenius*, can only be the result of multiple invasions. In the four genera with a single endemic and one or two non-endemic species, multiple invasions are almost certainly responsible. The populations considered endemic are those which have been modified during the course of their inhabitation of Lake Tanganyika. Probably they were introduced earlier than the non-endemic species.

Only two Nyasan associations are undoubtedly attributable to multiple invasions alone. These are *Ctenopoma* and *Gnathonemus*. [N.B. Worthington (1933), in assigning the specimens from Lakes Nyasa and Bangweulu to Boulenger's species *C. ctenotis* indicated the probability that *C. ctenotis* may be but synonymous with *C. nanum*, a Congo species. Poll (1946) has questioned the distinction of *C. ctenotis* Boulenger from *C. muriei*, which occurs in Lakes Tanganyika, Victoria, Edward, and the Nile.] Determinations of the relative importance of the two factors are more difficult for the other three associations. In *Clarias* with four

TABLE 9

Modes of formation of the piscine species associations in Lakes Tanganyika and Nyasa

Tanganyika

		NON-ENDEMIC SPECIES WITH DISTRIBUTION OUTSIDE LAKE	
MULTIPLE INVASIONS	*Clarias* 3P	*C. mossambicus*	East Africa to Zambesi; Lakes Nyasa, Victoria, Kivu; Congo
		C. liocephalus	Congo basin
		C. theodorae	Congo (Katanga), Zambesi, Lakes Nyasa and Bangweulu, Rhodesia
	Marcusenius 2P	*M. nigricans*	Lake Victoria
		M. discorhynchus	Congo (Katanga), Zambesi, Lake Nyasa
	Alestes 2P, 1E	*A. imberi*	Congo basin, Rv. Rovuma to Limpolo, Lake Nyasa
		A. macrophthalmus	Gabon and Congo basin
	Barilius 2P, 1E	*B. salmolucius*	Congo basin
		B. moorii	Lakes Kivu and Rukwa
	Varicorhynchus 1P, 1E	*V. ruandae*	Ruanda
	Engraulicypris 1P, 1E	*E. congicus*	Congo basin, Subspecies in Lake Rukwa
MULTIPLE INVASIONS PLUS INTRALACUSTRINE CLEAVAGE	*Barbus* 2P, 4E	*B. aphantogramma*	East Africa and Lake Kivu
		B. serrifer	Lakes Edward and Kivu
	Synodontis 1P, 4E	*S. melanostictus*	Congo basin, Zambesi
	Mastacembelus 1P, 6E	*M. taeniatus*	Katanga (Congo) ?

Nyasa

MULTIPLE INVASIONS	*Ctenopoma* 2P	*C. multispinus*	Zambesi, Lake Mweru, Bechuanaland
		C. ctenotis	? See note in text
	Gnathonemus 1P, 1E	*G. macrolepidotus*	Zambesi
MULTIPLE INVASIONS (PLUS INTRALACUSTRINE CLEAVAGE?)	*Clarias* 4P, 2E	*C. mossambicus*	East Africa to Zambesi, Lakes Tanganyika and Victoria, Congo
		C. mellandi	Lake Bangweulu
		C. carsonii	Uganda
		C. theodorae	Zambesi, Congo (Katanga), Lakes Tanganyika and Bangweulu, Rhodesia
	Labeo 2P, 2E	*L. altilevis*	Zambesi
		L. cylindricus	East Africa to Zambesi, Lake Tanganyika
	Barbus 6P, 8E	*B. trimaculatus*	Zambesi, Transvaal, Zululand
		B. paludinosus	East and South Africa (including Zambesi)
		B. eutaenia	Zambesi, Angola, Transvaal
		B. banguelensis	Lake Bangweulu, Kafubo River (Congo)
		B. innocens	Lake Rukwa, Wami and Mkata Rvs. (Tanganyika Terr.)
		B. rogersi	Upper Zambesi, Angola

non-endemic and two endemic species, and in *Labeo* with two endemics and two non-endemics, it is probable that the endemics of each genus are the result of early double invasions. However, the possibility of intralacustrine cleavage cannot be excluded. *Barbus* presents further difficulties. The six non-endemic species are certainly the result of multiple invasions. How many of the eight endemics are also? This question can only be answered by an authority. From Worthington's (1933) treatment of this genus it appears that four endemic species (*B. rhoadesii*, *B. eurystomus*, *B. johnstonii*, and *B. globiceps*) are closely related, and therefore it may be considered possible that they arose with the lake. The other three endemic species (the fourth having been considered questionable by Worthington) do not appear to form a group with the genus. Presumably they represent three relatively old invasions.

This total of ten invasions by species of *Barbus* is not as improbable as it first appears, because of the exceedingly large number of species of *Barbus* in the rivers of East and South Africa. *Barbus*, indeed, dominates the fish fauna of this region (Nichols, 1928). Within the Tanganyika drainage basin there are 13 species of *Barbus* restricted to the rivers. Six are endemic. All have presumably invaded this drainage basin. Two occur otherwise only in East African rivers and must have entered the Tanganyika basin from the east. One (*B. pellegrini*) came from Lake Kivu. The other non-endemic species have wider distributions, including the Congo system, and probably entered through the Lukuga. The distribution of the non-endemic Nyasan *Barbus* furnishes some notion of the paths over which the lake may have been invaded. Four have wide distributions, including the Zambezi. Presumably they entered from some part of this system, not necessarily up the Shire, which is blocked by the Murchison Rapids. *B. innocens* has been found outside Lake Nyasa in Lake Rukwa and in the Wami and Mkata Rivers in Tanganyika Territory. Perhaps it entered the Nyasa basin from the northeast. *B. banguelensis* is restricted to Lake Nyasa, Lake Bangweulu, and the Kafubo River (Katanga region of Congo). This distribution can be interpreted either as an invasion of Nyasa from the west or from Nyasa into the rivers to the west of the Nyasa basin.

The differences in the roles which multiple invasions have played in the development of the piscine species associations of Lakes Tanganyika and Nyasa are related to their positions with respect to the rich Nile-West African and poorer East and South African freshwater fish faunas (Nichols, 1928). Lake Tanganyika has recently received contributions from the Nile-West African fauna through the Lukuga and, to a much smaller extent, from the north through Lake Kivu. Three species of *Barbus* of the Tanganyika drainage, of which only one lives in the lake, *Labeo cylindricus*, and the riverine *Amphilius platychir* are the only species which have almost certainly come from the East and South African fauna. The Nyasan fish fauna has been largely recruited from the relatively poor East and South African fauna. The dominance of *Barbus* here is reflected in the fact that Lake Nyasa has twice as many species as Lake Tanganyika. Only a single Nyasan species *Barbus banguelensis* occurs in the Congo system. The interpretation of this distribution has been discussed. The cichlid stocks were probably also derived from the East and South African faunas.

In the discussion of the species associations of the copepods of the genus *Eucyclops* the four endemic species were considered to form a flock which had evolved in the lake. The presence of three other non-endemic species of the same genus provides evidence of passive multiple invasions. Two of these, originally described by Sars from Lake Tanganyika, have been subsequently discovered elsewhere. *E. agiloides* (Sars) has been recorded from many other places in Africa, southern India, and the Sunda Islands (Kiefer, 1929, 1932, 1934a, b, 1939). *E. euacanthus* (Sars) is known to occur in western and southern Africa and in the Sunda Islands, (Kiefer, 1929, 1934a, b, 1939). The third species, *E. angustus*, originally described from Lakes Tanganyika and Nyasa, has not been taken elsewhere. The unmodified populations of *E. agiloides* and *E. euacanthus* may be relatively recent invasions. It is possible that the species of *Eucyclops* and *Microcyclops* now considered endemic in Lake Tanganyika may also be shown to exist elsewhere as the tropical freshwaters of the Old World become better known.

SPECIES ASSOCIATIONS IN OTHER LAKES

Large species associations have been discovered in five other lakes. None of these associations approach in magnitude those found in the three lakes previously considered. The fauna of only one of these lakes, Victoria Nyanza, is sufficiently known to merit discussion. It has one large species association. Lake Titicaca, high in the Andes, has two species associations. Insufficient data on the intralacustrine distribution of the faunal elements are at present available. The complete results of the Percy Sladen Trust Expedition to Lake Titicaca in 1937 will undoubtedly provide much of the desired information. The other three lakes are smaller in size and have smaller species associations. Lake Lanao on Mindanao in the Philippine Islands is reported to have at least 17 closely related species of cyprinids in its waters. Lake Ochrid, lying near the junction of Greece, Jugoslavia, and Albania, has in its fauna several small species groups. Species associations have been reported among the prawns, molluscs, and fish common to the five small lakes of the isolated Malili River drainage of central Celebes.

Lake Victoria or Victoria Nyanza

The basin of Lake Victoria is about as different in shape from those of Baikal, Tanganyika, and Nyasa as could be (Fig. 6). It is like a tremendous saucer, with an area of about 69,000 sq. km. (26,000 sq. mi.), and a maximum depth of 80 m. Even this depth is exceptional, and over most of the central portion of the lake no depths of more than 70 m. can be found. The coast line is extremely irregular, with many small bays and islands near the shore. There are three large gulfs, Kavirondo Gulf in the northeast part, Speke Gulf to the southeast, and Emin Pasha Gulf to the southwest. The only regular stretch of shore is along the west side of the lake. The Sesse Islands form an archipelago in the northwest corner of the lake.

Worthington has studied (1930) the physics and chemistry of the lake water, and found a striking difference between the gulfs and the open waters of the lake. The transparency of the open waters measured with Secchi's disc varied between 6 and 8 m., while in Kavirondo Gulf, which was assumed to be a typical gulf, the transparency was from one half to one-and-one half m. The great turbidity of the gulf is due to two factors. Phytoplankton is more abundant and there is a considerable amount of suspended detritus, as these gulfs are shallow enough (10–20 m.) to be mixed to the bottom. The temperature of the gulfs tends to be slightly higher than the upper layer of similar thickness in the open part of the lake where the temperature is about 25°C., dropping gradually to 23.3°C. at the bottom. Complete diurnal mixing takes place in the upper 20 m. of water, which are probably saturated with oxygen, although no determinations were made. Water below this depth is never fully mixed, according to Worthington, although there is sufficient secondary turbulence to maintain a low oxygen concentration on the bottom, which is inhabited chiefly by chironomid larvae (Worthington, 1930). A few oligochaetes and prawns apparently can exist here as well (Graham, 1929). The deeper parts of the bottom in the gulfs are also populated primarily by chironomids.

The fauna of Victoria Nyanza has been catalogued by Cunnington (1920) and, except for the fish, there have been few changes or additions since. The faunas of both Victoria Nyanza and Lake Kioga are very different from that characteristic of the Nile. There is good reason to believe that Victoria Nyanza, like Lake Edward, was reduced to a swamp-like condition during the first interpluvial period. This extreme reduction of the former lake caused the extinction of all but a few Nilotic species. Since Lake Victoria has refilled, its waters have been repopulated from the survivors with a few additions from adjoining waters. Murchison Falls has prevented the invasion of Nilotic fish. The most recent list of the fish, given by Graham (1929), includes the new species collected by the Fisheries Survey of 1927–1928. Several small species associations among the invertebrates are undoubtedly the result of multiple invasions. By far the largest association within the lake is that of the genus *Haplochromis* and a few closely related fish placed in other genera. This is a species flock. Graham's list gives 55 endemic species of *Haplochromis* and one Nilotic species, *Haplochromis multicolor* (Hilg.). In addition to these, Regan (1922) has separated four deviant species of the *Haplochromis* stock into four genera, *Astatoreochromis*, *Macropleurodus*, *Hoplotilapia*, and *Platytaeniodus*.

Subsequent to this survey of Victoria Nyanza, the Cambridge Expedition to the East African Lakes explored several lakes directly to the west of Victoria Nyanza and discovered *Haplochromis* populations very similar to those hitherto considered as endemic to Lake Victoria. The most westerly and by far the largest of these lakes is Edward, occupying a downwarp of the Western Rift. The other lakes are small and swampy, and constitute part of one of the peculiar drainage systems which drain both east into Victoria Nyanza and west into Lake Edward (Fig. 6). Those investigated are Nakavali, Kachira, and Kijanebalola (Worthington, 1932). The noncichlid fish were treated in 1932 by Worthington, and Trewavas published an account of the cichlids in 1933. Twenty species of *Haplochromis* were found in Lake Edward, four of them species previously thought to be restricted to Lake Victoria.

This close relationship is further emphasized by the fact that the 17 endemic species in Lake Edward are all closely related to Victoria species. Two other cichlids from Lake Edward belong to monotypic genera clearly derived from *Haplochromis*. One is *Astatoreochromis alluaudi* Pell., common in Victoria, while the other, *Schubotzia eduardiana* Blgr., occurs only in Lake Edward. An examination of the fish of the three small, swampy lakes proved that *Haplochromis nubilus* Blgr., one of the few species common to Edward and Victoria, also occurs in all three small lakes, and that *Astatoreochromis alluaudi* occurs in two of them.

The recent fish fauna of Lake Edward has obviously been derived from Victoria by means of the drainage systems connecting the two lakes, rather than from Lake Albert through the Semliki River, which drains Edward. During the early Pleistocene Lake Edward contained Nilotic fauna, judging from the fossil remains of crocodile and *Lates* in the Kaiso beds near the lake (Fuchs, 1934). The present fauna lacks these Nilotic elements, which are presumed to have been destroyed during the arid first interpluvial period. The Semliki Falls has acted as a barrier to the passage of the Nilotic fauna from Lake Albert into Lake Edward just as the Murchison Falls has prevented its penetration into Lakes Kioga and Victoria.

The *Haplochromis* species of this Victoria-Edward system differ from each other primarily in the size and shape of the mouth and the number, structure, and arrangement of the teeth, and appear to form a natural group which has probably evolved from a single population. Trewavas (1948) has expressed the belief that this parental species resembled *H. wingatii* of the Upper Nile and *H. bloyeti* of Tanganyika Territory.

Although fish of the *Haplochromis* stock have speciated tremendously in Victoria Nyanza, it will be remembered that there are almost twice as many species in the Lake Nyasa flock. Regan, who has studied the cichlids of all three lakes, has considered that those of Tanganyika are more differentiated than those of Nyasa, and these in turn more so than those of Victoria Nyanza. This is in accord with the geological evidence that Tanganyika is the oldest and Victoria Nyanza the youngest of the three lakes.

A consideration of the known facts about the ecology and distribution of the *Haplochromis* flock within Victoria Nyanza brings to light a most baffling problem, since many species are not restricted to the bottom, as was true of all of Lake Baikal's species flocks. Although a large part of the fish population occupies the inshore waters, especially the gulfs, many *Haplochromis* are found in the open waters as well, feeding chiefly upon the smaller *Engraulicypris*, a plankton-feeder. The same species also feeds on the bottom at shallow, intermediate depths, and a few may even feed on the deepest bottom. Indeed, Graham has concluded that one species, *H. guiarti*, is ubiquitous except perhaps in water deeper than 60 m.

The first step in an investigation of speciation in Victoria Nyanza is to determine whether there are any species of *Haplochromis* which are restricted in distribution to any geographically distinct regions of the present lake. Although there have been no studies directed primarily toward the elucidation of the *Haplochromis* distribution, the Fisheries Survey made 100 collections with different types of gear in many parts of the lake. The results of these collections have been reported in some detail (Graham, 1929) and it is possible to obtain some conception of the distribution of many species.

The majority of the species, while not frequently caught, were taken at widely separated points, so that a lake-wide distribution must be assigned them provisionally. Two species are not only widely distributed but also numerous, inasmuch as they are represented in a large number of catches. *H. guiarti* was present in a third of all collections, being taken most frequently in 2-inch mesh gill nets in both deep and shallow water, and in trawls and seines as well. This species apparently is present in all parts of the lake, with the possible exception of water deeper than 60 m. *H. cinereus* was taken in one-fifth of all collections, most frequently in trawls, indicating that it stays much closer to the bottom than *H. guiarti* does. This species certainly shuns the deepest bottom. *Astatoreochromis alluaudi* is among the most common, appearing in one-seventh of the catches.

Although it is reasonable to assume a lake-wide distribution on the basis of a small number of widely scattered collections, greater caution must be used in assuming a restricted distribution from a single catch. Eight species of *Haplochromis* were taken at single stations. Four of these, each with a single specimen taken, were collected in the northwest corner of the lake. In view of the fact that a greater number of collections was made here than anywhere else in the lake, these catches may only represent chance catches of species more widely distributed but rare everywhere. However, one species, *H. plagiostoma,* was taken six times around Kavirondo Gulf and near Port Victoria just to the north. A single specimen was taken in each of three gill nettings, yet two were taken in a trawl near Port Victoria, seven in a trawl in Kavirondo, Gulf, and five from a basket trap near the Rusinga Islands at the mouth of the gulf. It seems likely that this species has a restricted distribution, although it is still far from certain. Another species *H. sauvagei,* was taken on three occasions near Port Victoria, twice in trawls yielding one and 18 specimens respectively, and once a solitary specimen in a gill net. Here again, it is likely but not certain that this species has such a limited range. Similar difficulties are attached to the interpretation of the single catch of single specimens of two other species in parts of the lake which were less intensively fished. The data for *H. bayoni* are more convincing. This species was taken four times in gill-nettings around the Sesse Islands and the islands of Damba and Kome just to the north and no where else. Although three nets held solitary specimens of *H. bayoni,* 20 were caught in the fourth. At present the interpretation that *H. bayoni* is confined to the waters around these islands of the northeast coast of the lake seems justified. Two other species, *H. argenteus* and *H. gowersii,* were each represented by single specimens in this much less intensively fished region and may similarly be restricted to it.

This appears to be the only portion of the lake to which some species are limited. The large gulfs, with the possible exception of Kavirondo, do not seem to be sufficiently isolated for their populations to have diverged genetically. It is not unexpected, in view of Worthington's observations, that the biota is dense in the shallow waters all around the lake.

Worthington's observations on Lake Nabugabo assume importance because they furnish a clue to the way in which *Haplochromis* populations can be isolated and diverge sufficiently to attain the rank of separate species. What is now called Lake Nabugabo was once a bay on the northeast coast of Victoria Nyanza (Fig. 6), but in the course of time the strong southeast winds have built a sand spit across its mouth which ultimately separated it completely from the body of the main lake (Worthington, 1933). Lake Nabugabo now contains *Tilapia, Clarias, Bagrus,* and *Haplochromis.* The species of the first three genera are the same as ones found in Victoria; however, only one of the four species of *Haplochromis* is a Victorian species, the others being endemic to Lake Nabugabo. Each is, however, closely related to a species in Victoria (Trewavas, 1933). Should this lake become continuous with Lake Victoria again, as a rise of several meters in the water level would certainly bring about, these Nabugabon species would be placed in competition with those already in Victoria. Such competition would lead to ecological specialization, because any genes which tended to lessen the degree of competition between the competing species would have selective advantage. Competing species would tend to occupy different ecological niches.

Lake Nabugabo, therefore, provides an illustration of the manner in which both benthic and pelagic species of *Haplochromis* can have arisen. The isolation of bays to form small peripheral lakes, which were subsequently reincorporated after a period of isolation short relative to the age of the main lake, could account for the origin of the *Haplochromis* flock. The main body of Victoria Nyanza would then be comparable to a large central island in an archipelago that accumulates species which have attained reproductive isolation on the smaller peripheral islands (Galapagos finches or Hawaiian drepanids, for example). Competition between these species leads either to changes in habit which reduce competition, or to extinction.

Geological observations indicate that the lake has been much more extensive in the past than it is at present (Wayland, 1934). Ancient shorelines extended as far as the rifts to the northwest and southeast. Beaches as far as 300 feet above the present lake level have been found. This does not necessarily mean that a lake 300 feet deeper than the present one ever existed, as the basin has very likely been tilted several times during the course of its history. However, it is clear that the lake has been more extensive than now and that its level has fluctuated considerably. This would afford ample opportunity for the isolation of peripheral lakes and their reincorporation.

The fact that the species of *Haplochromis* in Lake Nabugabo have diverged sufficiently to be considered specifically distinct, while the other populations have not become modified, indicates the relatively rapid rate at which *Haplochromis* can evolve. As mentioned during the discussion of the Nyasan cichlids, the reproductive behavior of these fish may be responsible for the preservation of differences which arise during temporary isolation (cf. p. 140).

If the *Haplochromis* stock has long been characterized by complex reproductive behavior, the period of isolation of a peripheral lake could have been relatively short and still sufficient for the isolated population to become so modified that it would be reproductively isolated when reintroduced into the main body of the lake. Also, from the absence of species flocks among the other genera, which appear to diverge more slowly, it may be deduced that the peripheral lakes which were reincorporated into the main lake had in general not been isolated for geologically long periods.

Estimates of the age of Lake Victoria vary considerably. Worthington (1937) has probably underestimated it at 15,000 to 20,000 years. According to Wayland (1934), a lake which existed at the same site during the early Pleistocene dried up more or less completely during the interpluvial period between his Pluvial I (Kageran) and Part 1 of Pluvial II (Kamasian). The lake reformed during the Kamasian pluvial. Wayland considered that the arid period succeeding the Kamasian pluvial was not sufficiently intense to cause this lake to lose its lacustrine character, although its size certainly dwindled. If his interpretation is correct, then Lake Victoria has persisted since the Kamasian pluvial. Kamasian is considered Middle Pleistocene (cf. Leakey, 1936) and contemporaneous with the Riss Alpine glaciation. The age of Lake Victoria would then be about 300,000 to 500,000 years, depending on the estimate of the total length of the Pleistocene. If, however, the lake did dry up during the Kamasian-Gamblian interpluvial, the present lake must have formed early in the Gamblian pluvial, or between 50,000 and 200,000 years ago. It is unlikely that any subsequent arid phases were sufficiently intense to bring about the desiccation of the lake.

According to Wayland's map of the region adjacent to Victoria Nyanza (1934, p. 349), there are two small lakes to the west of the southern half of the western coast of Victoria. These lakes, Ikimba and Burigi by name, are possibly other examples of peripheral lakes left by a shrinking Victoria and are worthy of investigation.

Lake Titicaca

Lake Titicaca has a total area (excluding islands) of 7600 sq. km. (Gilson, 1939). The main basin or Lago Grande is roughly elliptical with the major axis NW—SE. The maximum depth has been recorded at 281 m. At the southeast end of the main basin, connected by a narrow strait, is a shallow bay, Lago Pequeño. Shallow Puño Bay on the northern half of the western side of the lake is the only other major irregularity in the shoreline. The lake lies between 15° 14′ and 16° 35′ S., at an altitude of 3815 m. The lake is within a basin of internal drainage called the Altiplano, a downfaulted area between the Eastern and Western Cordilleras which extends from 14° to 22° S. To the south of the Titicaca basin there is another basin within the Altiplano which contains water. This is Lake Poopo, a vast brackish puddle with an area of about 2500 sq. km. and a depth of seldom more than 4 m. Titicaca drains into Poopo through the sluggish Desaguadero River. South of Lake Poopo, at the southern end of the Altiplano, there are vast salt flats.

At the northern end of the Lago Grande, and separated by only a few kilometers, are several small, probably shallow lakes, the largest of which are Lakes Arapa and Umayo. Arapa connects with the Rio Ramis, a few kilometers above its opening into Lake Titicaca. Umayo is west of Puño Bay. As these lakes are only a few meters higher than Titicaca, it is certain that they were until relatively recently a part of the large lake. These peripheral lakes are thus similar to those believed to have been important to the speciation of *Haplochromis* in Lake Victoria. Of quite a different nature are two lakes, Lagunilla Lagunilla and Lagunilla Saracocha, about 80 km. (50 mi.) west of Puña in the Western Cordilleras. They are about 300 meters higher than Lake Titicaca and were undoubtedly always separate from it, although it is probable that they have been connected with each other at some time in the past.

Moon has reviewed the history of the Altiplano (1939). During Miocene time tectonic movements led to the formation of the Altiplano, which has been a basin of internal drainage ever since. During the Pliocene the Altiplano was only a few hundred meters above sea level and supported a semitropical biota. Chiefly during the early Pleistocene the basin suffered uplift to its present elevation and without lateral displacement, and became increasingly arid the while. There are abundant indications of much higher lake levels, some or all of which have been attributed to the melting of glaciers during the Pleistocene. The Titicaca and Poopo basins were probably united in a large lake at one time.

A paucity of animal stocks comprises the biota of Titicaca. Although several widely distributed groups are represented by many cosmopolitan species (rotifers for example, recently treated by Beauchamp, 1939), there are only two piscine stocks. One siluroid, *Trichomycterus rivulatus*, inhabits the waters of the Titicaca basin as well as those of other parts of Peru and Bolivia (Tschernavin, 1944b). A cyprinodont stock is represented by 18 species in the Altiplano. Two of these 18 also occur in river systems draining the outer sides of the mountains rimming the Altiplano. Only two species do not occur in the Altiplano, each of them being restricted to a lake in the valley to the north of the Altiplano, that of the Urubamba River. These 20 species are considered to constitute the subfamily Orestiinae. Their geographical distribution indicates that the Altiplano has been the site of their evolution, and they are the most remarkable element of its biota. The only other vertebrates in Lake Titicaca are the entirely aquatic frogs of the Andean genus *Telmatobius*.

Not only are the amphipods the only group of malacostracans described from Titicaca, but they are the most interesting of all its crustaceans. The planktonic cladocerans and copepods (Birge, 1906; Marsh, 1906) show nothing remarkable from the point of view of a student of evolution. Unlike those of Baikal, these amphipods are taltrids and the 11 species described belong to *Hyalella* Smith, a genus characteristic of the freshwaters of both North and South America and the sole amphipod genus so far known from continental South America (Shoemaker, 1942). More will be said of this species association.

According to Bavay (1906), nine genera of molluscs are represented in Lakes Titicaca and Poopo. Two genera appear to have species pairs. All other genera are represented by single species. It seems advisable to defer discussion of these molluscs until the latest collection has been studied.

The three species associations to be considered are those of the Orestiinae, *Hyalella* and *Telmatobius*. Tchernavin's thorough study (1944a) of the taxonomy of *Orestias*, together with the little that is known of the ecology and distribution of its species, has made it possible to comprehend the problem involved. Tchernavin has arranged the 20 described species into four groups which are of generic or subgeneric rank. Not all four groups are equally well defined. Group II is the largest, with 8 species, all rather large in size and inhabiting streams, rivers, pools and lakes not only within the Altiplano but also to the north as far as Lake Junin, Peru, and southward to Lago d'Ascotan, Chile, west of the southern end of the Altiplano. Groups III, IV, and I, with 6, 4, and 2 species represented, respectively, are restricted (with one questionable exception) to Lake Titicaca. The two large-sized species of Group I are the only pelagic members of the subfamily, according to Tchernavin. The origin of these two closely related pelagic species must date from a time when Titicaca was subdivided into at least two separate basins. A few specimens in which the characteristics of the two species are curiously combined have been considered hybrids by Tchernavin. Garman described with great inexactitude a "variety" of one of these species, *O. pentlandii*, from the Urubamba River to the north of the Altiplano. Tchernavin has not included this "variety" of Garman's because of the inadequacy of the description. It is inherently improbable that one of the pelagic species from Lake Titicaca could have passed over the mountain range separating the two drainage systems, although headwater species certainly have done so.

The members of Group III, all of small size, occur in the shallow waters of Lake Titicaca. Tchernavin considers this a rather artificial grouping. The four species of Group IV, on the other hand, apparently constitute a well-defined group which might be considered a genus. All species have been taken from greater depths of the lake than have any of the other species, viz., between 20 and 38 m.

All these species have undoubtedly originated within the Altiplano through geographical isolation.

The report on the amphipods taken by the Percy Sladen Trust Expedition has not yet appeared. Our knowledge of this group is based upon Faxon's 1876 report on the collections of the Agassiz-Garman Expedition of 1875 and Chevreux's (1906) study of Neveu-Lemaire's collections made in 1903.

All 11 described species are members of the bottom communities of Lake Titicaca. None have been reported from saline Lake Poopo or any of the other freshwaters of the Altiplano. Little is known of the intralacustrine distribution of the species. Agassiz and Garman collected from considerable depths (as great as 120 m.) several species which in their spinosity bear a resemblance to certain of the Baikalian gammarids. Neveu-Lemaire did not succeed in making collections at any great depth. The four new species which Chevreux described occur in shallow water, and four of Faxon's deep-water species were not retaken by the second expedition. It is probable that these species comprise a flock which had its origin in the lake.

Telmatobius is more like *Orestias* than *Hyalella*, in that there is a widespread Andean fluviatile species *T. marmoratus*, which inhabits most of the rivers and streams within the Altiplano. Morphological comparisons accord with the distributional evidence in indicating that this species is more primitive than the two lacustrine species which are restricted to certain lakes of the Altiplano. One of these, *T. culeus*, occurs in its typical form only in the Lago Grande. However, a distinctly different form, *T. c. albiventris*, inhabits Puño Bay, Lago Pequeño, and Lake Arapa. The populations in these three geographically discontinuous shallow waters are closely similar. Parker (1940) was unable to decide whether these three populations are relicts of a population continuous in the recent geological pst, when the lake was higher, or whether they represent three geographically separate divergences from a population like the typical form. The second lacustrine species, *T. escomeli*, lives in the two Lagunillas to the west of Lake Titicaca. It will be remembered that these lakes are about 300 m. higher than Titicaca and probably were never connected with the lakes occupying the floor of the Altiplano. This species has apparently arisen from *T. mamoratus* independently of *T. culeus* in a lake which probably included the two present lakes. Each of the two present Lagunillas has a peculiar subspecies.

Lake Ochrid

This brief notice of the evolutionary problems presented by the fauna of Lake Ochrid is based primarily upon information marshalled by Stanković (1932) in his review of the data concerning the lake and its fauna.

Lake Ochrid lies on the Albanian-Jugoslav border and is small relative to those with which we have been previously concerned. Lake Titicaca is by far the smallest of these, and its Lago Grande alone covers an area over 20 times larger than Lake Ochrid (270 sq. km.). However, Ochrid matches Titicaca in depth. Its maximum depth, 286 m., is five meters greater than any yet found in Titicaca and, like the Lago Grande, much of the bottom lies under more than 200 meters of water. For its size Ochrid is relatively deep. Its basin is regular and steep-sided. In some places it is possible to sound 230 m. only 300 m. from shore! All geologists who have studied the region agree that the lake occupies a graben formed or, at least rejuvenated, by recent down-faulting. The amount of surface run-off in the steep-sided depression largely occupied by the lake is small, most of the water being supplied by numerous and large springs both above and below the surface of the lake. The northern rim of its elliptical basin is low and over it the lake finds its outlet as the Drim River, flowing northward through Albania to the Adriatic Sea.

The fauna of Lake Ochrid is not only distinguished through the presence of a fair proportion of endemic subspecies and species, but also the majority of stocks are not those found largely expanded throughout the freshwaters of western Eurasia.

A consideration of the fish fauna of Ochrid is illustrative. Thirteen of 18 populations are taxonomically distinct. Ten of these are represented by populations best considered geographical subspecies. Two populations restricted to Ochrid are specifically distinct. A third is restricted to the Drim system (including Lake Scutari). There is not even one species pair, let alone any flocks in Ochrid, in which aspect this lake differs from all of those previously considered. The fish fauna of that part of the Balkans draining into the Adriatic is distinct from that of the Danube basin and central Europe and even from that of the Balkans whose rivers flow into the Aegean. The western part of the Balkan peninsula most resembles southern Europe in the composition of its fish fauna, yet shows some indication of similarity to the freshwaters of northeastern Asia. The two salmonids of Lake Ochrid illustrate these patterns of distribution. Endemic *Trutta balcanicus* was considered by Karaman (cited in Stanković, 1932) to be similar to *T. carpio* of Lake Garda (Northern Italy). Berg (cited in Stanović, 1932) placed the other endemic salmonid together with *S. obtusirostris*, a Dalmatian endemic, in the genus *Sal-*

mothymus, which he related to the Siberian *Brachymystex*. The nearest relatives of at least two west Balkan genera of cyprinids (*Paraphoxinus* and *Leuciscus*) which occur in Lake Ochrid are to be found in northeastern Asia (Berg, in Stanković, 1932).

It has been previously mentioned that 13 of the 16 known species of the oligochaete genus *Lamprodrilus* live in Lake Baikal. One of these, *L. pygmaeus*, also occurs in Ochrid as a subspecies. This remarkable link between Ochrid and Baikal has a parallel in *L. isoporus*, which was considered a Baikalian endemic until Svetlov (1936) reported a subspecies from Lakes Ladoga and Onega of Baltic Russia. The three species which do not occur in these lakes live in northeastern Siberia, Macedonia, and Bohemia, respectively, which distribution strenghens the faunal similarity between the Balkan region of Europe and the northeastern part of Asia.

The rissoid (hydrobiid) snails of Lake Ochrid show southern European, Siberian, and also Ponto-Caspian affinities. *Pyrgula* (*Pyrgula*), which is represented in Ochrid by three species, is known to have only one other extant species, and that from Dalmatia and Lombardy. Two other rissoids, *Trachyochrida filocincta* and *Stankovičia baicaliiformis*, are said to be allied to the Caspian *Micromelania* and the Baikalian *Baicalia*, but the degree of affinity is uncertain, not only because the taxonomy of this entire assemblage of rissoid snails is unsatisfactory, but even more because both species are known only by empty shells (Polinski, 1932).

As certain of the Ochrid stocks with relict distributions are also found in other Balkan freshwaters, Lake Ochrid cannot be regarded as a solitary stronghold where ancient species have maintained themselves against recent invaders. It is, on the contrary, but a part of the freshwaters of the Balkan peninsula, which with their tremendous subterranean ramifications have been able to resist faunal changes.

Our chief interest lies with the larger species associations of Lake Ochrid. Many are clearly associations which owe their origin to multiple invasions. Georgevitsch (1906) reported four species of the hygrobatid watermites of the genus *Piona* from Ochrid, all non-endemic. Two species of amphipods both belonging to the same subgenus of *Gammarus* live in Lake Ochrid. *G.* (*Rivulogammarus*) *ochridanus* is an endemic representative of *G.* (*R.*) *balcanicus* which occurs in the Balkans, Crimea and Asia Minor. The other species is *G.* (*R.*) *roeselii*, a central European form which extends into the Balkans (Schellenberg, 1937, 1943). The tubificid oligochaete *Peloscolex* is represented in Lake Ochrid by two species, *P. stankovici* and *P. tenuis* (Hrabě, 1931). *P. stankovici* is an endemic species most closely related to the European *P. velutinus*. *P. tenuis* also occurs in Lake Prespa, a shallow lake several km. to the southeast of Ochrid and, according to at least one geologist, once continuous with Ochrid. *P. tenuis* approaches the European *P. ferox* most closely and apparently represents an invasion by this parent species or its ancestor relatively early in the history of Ochrid.

Several other species associations can probably be attributed to multiple invasions, but the possibility of intralacustrine speciation cannot be eliminated. The most interesting example is that presented by another tubificid genus, *Ilyodrilus*, with three species in Ochrid. *I. hammonensis* is widely distributed throughout Europe, including Lake Prespa. Endemic *I. ochridanus* is most like a population in Lake Prespa, considered as endemic, *I. prespaensis*. This and *Peloscolex tenuis* are the only recorded stocks which are restricted to these two lakes which may once have been united. The third species in Lake Ochrid, *I. isochaetus*, is also endemic. It has been impossible to surmise the relationship of these two endemics to other species of the genus. *I. hammonensis* and *I. ochridanus* are among the commonest oligochaetes in Lake Ochrid, but *I. isochaetus* occurred in only three bottom samples. However, in these three, the two common species were absent. If this distribution was not fortuitous, it is the only evidence that any closely related species in Ochrid have allopatric distributions.

A major taxonomic problem is presented by the existence of four oligochaete species which are represented by subpopulations with somewhat different but widely overlapping vertical ranges. These may have arisen either by multiple invasions or by intralacustrine cleavage. If these subpopulations indeed coexist, as they appear to, they must be reproductively isolated and probably should be considered species. They have been called "Forms." *Tubifex* (*Psammoryctes*) *ochridanus* f. *typica* is characteristic of the deep water of Lake Ochrid, being replaced by *f. variabilis* in the shallower waters, yet in shallow Lake Prespa *typica* alone occurs. This indicates that competition is important in limiting the vertical range. In *Rhyn-*

chelmis komareki, on the other hand, the difference between the forms is a matter of head shape, and has a precise parallel in the dimorphic Baikalian *R. brachycephalis*, in which species abyssal specimens have shorter, rounder heads. These might be merely environmentally determined differences in single populations. Hrabě has described three forms of *Peloscolex stankovicia* from Lake Ochrid. Adults of f. *typica* with 30–35 segments average 6 mm. in length. The majority of the *typica* occurred deeper than either of the others. Adults of *sublittoralis* ranged between 12–18 mm. in length with 60–70 body segments. A few specimens found at the very surface were 24 mm. long and had 115 segments. These Hrabě called *littoralis*. Whether this is a single polymorphic population or three separate ones can only be decided by careful investigation.

The last instance of a species with two Ochrid "forms" has several peculiar aspects. The species in question, *Eiseniella ochridana*, belongs to a lumbricid genus with amphibious habits. The two forms are *profunda*, with the male genital pores on the 13th segment, and *stankovici*, with the pores on the 15th; the former was found in bottom samples taken between 20–250 m., while the latter has been taken only between 40–100 m. The widely spread European *Eiseniella tetraedra* is the only lumbricid in which populations exist some of which have the male pores on the 13th, others on the 15th segment. Curiously enough there is another aquatic lumbricid in Lake Ochrid, one which was named *Allolobophora lacustris* by Černosvitov (1931), and which also occurs in two forms with the male pores on the 13th and 15th segments, respectively. Although this worm bears some resemblance to the previous one, Černosvitov decided that it most resembled *Allolobophora*. Yet he has pointed out the near impossibility of generic assignments in the Lumbricidae. The taxonomy and biology of these lumbricids need further investigation.

Intralucustrine speciation must be considered probable in the origin of associations in two genera of snails and one among the turbellaria. The prosobranchiate snail *Pyrgula* and the pulmonate *Gyraulus* have each an endemic subgenus in Lake Ochrid, in addition to several species. *Pyrgula* (*Pyrgula*) has three species endemic to Ochrid. Only one other living species of this subgenus is known, and it lives in Lombardy and Dalmatia. Although the only known extant members of the subgenus *Carinogyraulus*, four in number, are restricted to Lake Ochrid, the subgenus did not evolve in the lake, if the assignment of certain Miocene shells to this subgenus is correct (Stanković, 1932). The vertical distribution of the members of these two associations was given by Polinski (1932). *P.* (*P.*) *macedonia* inhabits the zone from 5–20 m.; *P.* (*P.*) *pavlovići* is characteristic of the zone from 20–30 m.; *P.* (*P.*) *wagneri* is an abyssal form living below 50 m. One species of *Carinogyraulus* lives in the upper 5 m. of water; another is chiefly found between 5–20 m.; the third is abyssal. The fourth species (*paradoxa*) was taken only once, in 1891. The horizontal distribution of these species is not known.

Stanković (1932) has recorded seven dendrocoelids (turbellaria) from Lake Ochrid and the springs feeding it. *Dendrocoelum lacteum* and *D. nausicaae* are known outside the basin, while the other five are restricted to it. *D. nausicaae* and the endemic species were ascribed by Stanković and Komárek (1927) to a new genus *Neodendrocoelum*, but Kenk (1930) has found no justification for this generic distinction, removing them to *Dendrocoelum*. It is not possible to determine whether the five endemic species of *Dendrocoelum* constitute a species flock. *D. jablanicensis* is restricted to a spring on the north shore of the lake and *D. st. naumi* appears to occur only in springs on the south shore, from data given by Stanković and Komárek (1927), although Stanković (1932) did not explicitly state, as he did for the former species, that it is restricted to springs. *D. nausicaae* and *D. maculatum* have been taken both in springs and in the littoral zone of the lake. *D. ochridense* alone is stated to occur only in the lake, and has been taken in dredges at depths of 40 and 108 m. From its name it may be assumed that *D. lacustre* occurs in the lake, but nothing further has appeared concerning its ecology.

Five closely related species of the ostracodan genus *Candona* constitute the only indisputable, large species flock in Lake Ochrid. Klie (1939) described these from the deeper areas of the lake bottom (below 10 m.). The members of the flock (*C. alta*, *media*, *trapeziformis*, *cristatella*, and *depressa*) are similar to the common European *C. neglecta*. Although Holmes (1937), in his study of the littoral ostracods, reported a few specimens of *C. neglecta* from depths of 10–30 meters, Klie did not find this widespread species in the samples which he studied. It is probable that Holmes' specimens actually pertain to an endemic species similar to *C. neglecta*. Two other non-endemic species (*C. candida*, *C. fabaeformis*) and one endemic (*C. triangulata*) have been reported from Ochrid, none of which are close to the *neglecta* group.

Two other genera of ostracods, *Limnocythere* and *Leptocythere*, are each represented by three closely related species in Lake Ochrid, these having probably evolved in the lake. *Leptocythere* was unknown from freshwaters until Klie (1939) described the three Ochrid species and a fourth from the Danube basin.

In the present state of our knowledge the *Candona* group of five species is the largest association in Ochrid which has probably arisen through intralacustrine cleavage, with one or two four-membered associations [*Carinogyraulus* and *Dendrocoelum* (?)] and several three-membered flocks. The general features of the vertical distribution of the members of some flocks are known and have been indicated, but the horizontal distribution has never been investigated for any, making it impossible even to hazard a guess about the nature of the geographical barriers involved. The maximum length of time within which these flocks have developed is uncertain. Probably the basin has held water since the late Pliocene, giving this lake an antiquity of the order of that of Lake Tanganyika.

Lake Lanao

Lake Lanao on Mindanao, Philippines, is slightly larger than Lake Ochrid, for it has an area of 375 sq. km. and a maximum depth of 300 m. (These dimensions given by Herre, 1933, are at variance with those of Halbfass, 1922, who stated the area to be 900 sq. km. and the greatest depth 112 m.) The cyprinids are the only remarkable element of the fauna, there being 17 closely related species of these fishes in Lake Lanao and the waters connected with it, whereas no flocks are known among the other groups which have been investigated, although single endemic species occur. From the collections of R. Woltereck, who visited the lake on his Wallacea Expedition, Brehm (1933a) described an endemic copepod which he named ***Tropodiaptomus gigantoviger*** for the two large eggs carried by the female. Balss (1937) described an endemic crab *Parathelpusa* (*Barythelpusa*) *woltereckі*.

Only the broad features of the geological history of this region of northwestern Mindanao are known, but it is apparent that Lake Lanao owes its origin to the damming of the headwaters of a mountain stream by a lava flow at some unknown time in the probably not too distant past. These impounded waters filled the deep ravine in which the stream had flowed, forming a lake deepest near the dam at the southern end. A trough, which was the river valley, trends north-south nearer the western shore. Great areas of shallow water, from 4 to 10 meters deep, extend out from the northern, eastern, and southeastern shores. The water has overflowed the northwest corner of the lake and runs, as the torrential Agus River, to the not far distant ocean. The lower course of the river is interrupted by the Maria Cristina Falls, which drop 65 meters (Herre, 1933). As Lake Lanao lies on an isolated plateau, it is completely cut off from the other freshwaters of the island.

The poverty of the fish stocks is marked. There are only two fish, an eel and a species of *Ophiocephalus*, in addition to the cyprinid species flock which Herre was certain has developed from a single headwater species. The eel has apparently penetrated the lake through underground channels which can be seen emerging at the foot of Maria Cristina Falls. The presence of underground channels is not surprising because that region of Mindanao is overlain coral rock. Herre believed that *Ophiocephalus striata* was introduced long ago by man, as has been done all over Malaysia.

Barbodes binotatus, a Malayan fish which has invaded the southern Philippines and spread over most of Mindanao, is considered the undoubted ancestor of the Lanao cyprinids, five of which exhibit sufficient morphological divergence to be placed in other genera. These three genera are distinguished from *Barbodes* primarily by the structure of the lower jaw. *Mandibularia resinus*, the species most divergent in jaw structure, is also a fish of entirely different ecological relations from the other members of the flock, for it "has taken to life in the boiling eddies and swirling mad torrent of the Agus, the outlet of Lake Lanao" (Herre, 1933, p. 160).

Herre constructed a phylogeny of the Lanao cyprinids and added what he had observed of the ecology of various lines. *Barbodes tumba* inhabits all of the mountain streams and lakes of the isolated Lanao plateau with the apparent exception of Lake Lanao itself. The adaptation of a species to life in the outlet has been mentioned. Four closely related species live in the clear water over bottom from 5 to 15 meters deep, from which grow forests of *Potamogeton*. Two of the largest species of *Barbodes*, *clemensi* and *manalak*, which live in this same ecological situation in Lake Lanao, also live in other lakes of the Lanao plateau. At least one species, *B. baoulan*, is restricted to the deeper waters of Lake Lanao. Several other species dwell in the shallow muddy bays of this lake, which are tangled with aquatic vegetation.

Herre has been the only investigator of these fish and he presented his 1933 summary with the express purpose of interesting some student of speciation in this fascinating problem. So far no one has availed himself of this opportunity.

Lakes of the Malili River Drainage

The lakes of the Malili River drainage of central Celebes are different from all of the previously discussed old lakes because they form a system of lakes partially isolated from each other and completely isolated from other freshwaters. Most of the fauna is endemic, and many of the endemics belong to nine species flocks, all restricted to this lake system and having from two to eight members each. The members of a flock may inhabit the same lake or different lakes, or both.

As the connections between the lakes makes it likely that some lakes are more easily invaded than others, it is necessary to describe the lakes and rivers before considering the species flocks and their possible origins. Reference to the map (Fig. 8) will show that three of the five lakes, Matana, Mahalona, and Towuti, may be considered the central part of the system. The surface of Lake Matana is 382 m. above sea level and the relatively short Patea River which drains into Lake Mahalona descends 72 m., part of this drop occurring as a waterfall. The overflow from Lake Mahalona forms the Tominanga River which drains into Lake Towuti. The surface of Lake Towuti lies at an elevation of 293 m. The Tominanga River accomplishes this descent of 17 m. with only one series of rapids. Lake Towuti drains through the Malili River to the ocean at the head of the Gulf of Boni. There are 11 waterfalls along the upper half of the river's course. The two small peripheral lakes, Wawontoa and Masapi, are only indirectly joined with the central lakes. Wawontoa lies in the mountains to the east of Lake Towuti at an elevation of 586 m. and drains through an intermittent stream into the Tominanga River just

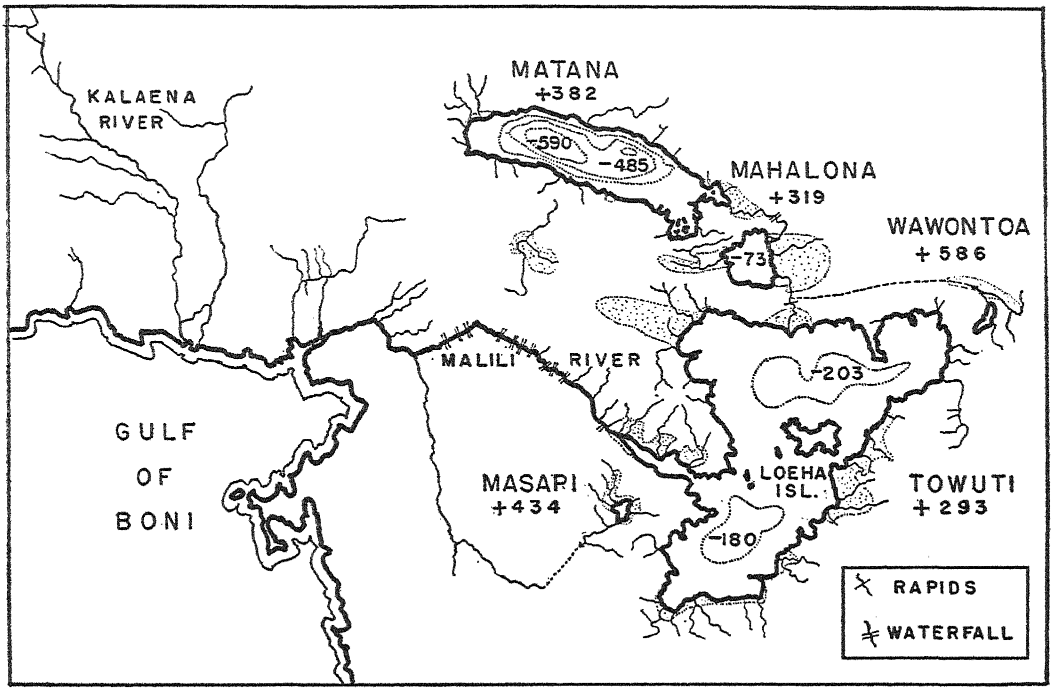

FIG. 8. LAKES OF THE ISOLATED MALILI RIVER SYSTEM, CENTRAL CELEBES (After Abendanon).

TABLE 10

Distribution of species flocks in lakes of Malili River system

SPECIES	MATANA	MAHALONA	TOWUTI	WAWONTOA	MASAPI
Crustacea—Prawns (Woltereck, 1937)					
Cardina masapi	+	+	+	+	+
Cardina lanceolata	+	+	+		
Cardina loëhae	+		+		
Cardina spinata	+		+		
Cardina lingkonae†			+		
Cardina tenuirostris			+ (Lingkone)		
Cardina towutensis			+ (Southern end)		
*Cardina opaensis**	+				
Crustacea—Copepods (Brehm, 1936b)					
Eodiaptomus woltereck wolterecki			+		
Eodiaptomus wolterecki matanensis	+				
Mollusca—Prosobranch Snails (Kruimel, 1918)					
Melania palicolarum		+	+	+	
Melania masapensis					+
Melania patriarchalis } rare	+				
Melania gemmifera } hybrids	+				
Melania towutica			+ (Loéha)		
Melania towutensis			+ (and Tominanga River)		
Melania mahalonica		+			
Melania mahalonensis		+			
Melania abendanoni				+	
Melania sarasinorum			+(Loéha)		
Melania lalemae			+		
Melania tominangensis			+ (Tominanga River)		
Melania insulae-sacrae			+ (Loéha)		
Mollusca—Pelecypods (Kruimel, 1918)					
Corbicula matanensis	+				
Corbicula mahalonensis		+			
Corbicula towutensis			+		
Corbicula loëhensis			+ (Loéha)		
Corbicula masapensis.					+
Fish—Atherinidae (Aurich, 1935b)					
Telmatherina celebensis	+	+	+	+	
Telmatherina abendanoni	+				
Telmatherina bonti			+		
Paratherina wolterecki		+			
Paratherina labiosa				+	
Paratherina striata			+	+	
Paratherina cyanea			+		
Fish—Cyprinodontidae (Aurich, 1935a)					
Aplocheirus marmotus		+	+		
Aplocheirus matanensis	+				
Fish—Gobiidae (Aurich, 1938)					
Glossogobius intermedius		+	+		
Glossogobius matanensis	+		+	+	
Stupidogobius flavipinnis			+		
*Vaimosa latifrons***	+	+	+		
Vaimosa sp.?			+		
	(13)	(11)	(26)	(7)	(3)

† pelagic.
* also in Lake Opa in SW. arm of Celebes.
** also in Kalaena River.

above the rapids. Lake Masapi is much more completely isolated, since its outlet, the Pongkeroe River, joins the Malili River below the cataracts. According to Abendanon's map, the Pangkeroe negotiates its descent of 434 m. without cataracts and its upper reaches are intermittent.

All of the animals represented by species flocks in these lakes tolerate fluviatile conditions. These lacustrine populations can presumably extend themselves downstream, and also upstream except over waterfalls. As we have no knowledge of other past connections or of how long the waterfalls of the extant rivers may have existed, we are forced to interpret the distribution of the species flocks in terms of the present physiography. The extent of Pleistocene sediments is indicated on the map (Fig. 8, stippled areas).

A tabulation (Table 10) of the distribution of these species flock indicates that Lake Towuti has more species than either Mahalona or Matana, as might be expected from its downstream position. The relative poverty of Lakes Wawontoa and Masapi is in accord with their relative isolation.

The presence of half as many species in Matana as in Towuti is not what would be expected if the fauna of Lake Matana had been derived from the lakes downstream. One explanation, namely, that Lake Towuti is the center from which Lake Mantana was populated at a time when there was no waterfall in the Patea River, is not consistent with the presence of the only non-endemic prawn, *Cardina opaensis*, in Matana but not in Towuti. The most reasonable assumption is that large, very deep Lake Mantana was one important part of the present Malili system in which the antecedent freshwater fauna of the region persisted during the tectonic movements which led to the formation and isolation of this portion of the Celebes. Although Lake Matana itself is of tectonic origin (graben), its formation probably dates from the initiation of these earth movements, while the remainder of the system was likely shaped by later movements. It is possible that some part of Lake Towuti also acted as a refuge for the antecedent fauna. The presence in Towuti of several groups of closely related species not represented in Matana (*Melania sarasinorum*, *M. lalemae*, *M. tominangensis*, *Corbicula towutensis*, *C. loëhensis*, *Paratherina*) can be adduced to support such a contention. However, their presence is as reasonably interpreted as the divergent results of early invasions from Lake Matana, possibly before Lake Mahalona was formed.

If it be assumed that Lake Matana is a center from which most if not all of the species flocks arose, it is then unexpected to find that Matana and Mahalona have no species which are common only to the two of them (cf. Table 10), although two species are common to these two lakes and Lake Towuti. It would appear that any species suf-

TABLE 11

Interlacustrine distribution of members of all Malili species flocks

(Based on Table 10)

MATANA—13 endemic species	
Matana only	7
Matana and Mahalona	0
Matana and Mahalona and Towuti	2
Matana and Towuti	2
All except Masapi	1
All five	1
	13
MAHALONA—11 endemic species	
Mahalona only	4
Mahalona and Towuti	4
Mahalona and Towuti and Wawontoa	1
All except Masapi	1
All five	1
	11
WAWONTOA—7 endemic species	
Wawontoa only	2
Wawontoa and Towuti	1
Wawontoa and Towuti and Matana	1
Wawontoa and Towuti and Mahalona	1
Wawontoa and Mahalona	0
All except Masapi	1
All five	1
	7
TOWUTI—26 endemic species	
Towuti only	15
(Single species with very close relatives in lake—3)	
Towuti species in Matana	6
Towuti species in lakes other than Matana	5
	26
MASAPI—3 endemic species	
Masapi	2
All five	1
	3

ficiently well adapted to fluviatile conditions to be able to spread into Mahalona from Matana is able to extend itself further downstream into Towuti and, in the case of two species, into other lakes as well. Further comment on the migration of species between lakes is unnecessary. The known facts are given in Tables 10 and 11, and their interpretation is left to the reader.

The apparent occurrence of intralacustrine speciation in both Matana and Towuti should be noted. There are four closely related species of *Cardina*, two of *Melania*, and two of *Telmatherina* in Lake Matana, where the possibility of multiple invasions has been fairly certainly excluded. In Lake Towuti the species mentioned previously as not occurring in Matana (3 of *Cardina*, 3 of *Melania*, 2 of *Corbicula* and 2 of *Paratherina*) have probably arisen within the lake.

A possible geographical basis for the intralacustrine speciation in Lake Matana is its subdivision into two basins. A major fault line, traceable as a scarp for many miles to the south, crosses Mantana between these two basins. The intralacustrine distribution of the fauna has not been studied. As Table 10 indicates, there is some evidence that members of the groups which have probably evolved in Lake Towuti have restricted distributions.

SUMMARY

Epitomizing this discussion of speciation in ancient lakes, it may be said that the gammarids of Lake Baikal are the only species flock the intralacustrine distribution of whose members is known with any degree of completeness. Many gammarid species and subspecies are restricted to geographically isolated and environmentally distinctive regions of the present Lake Baikal. The only reasonable explanation of their distribution pattern is that populations of these benthic organisms have been subdivided within the lake through the influence of geographical features. During their isolation these subpopulations have undergone genetic changes often of sufficient magnitude to effect reproductive isolation when the geograpical isolation breaks down. Subsequent interspecific competition results in the accentuation of adaptive differences. The high degree of ecological specialization which characterizes many lacustrine species flocks is thus attained through the competition of closely related species.

TABLE 12

Geographical bases of intralacustrine speciation

GEOGRAPHICAL CONFIGURATION	PROBABLE EXAMPLES	ORGANISMS INVOLVED	TYPE OF LAKE BASIN INVOLVED
Subdivision of the lake into large basins with subsequent amalgamation	BAIKAL TANGANYIKA (?) MATANA (?)	Benthic and pelagic	Deep lakes with multiple basins (graben en echelon?)
Formation of small peripheral lakes with subsequent reincorporation	VICTORIA NYANZA TITICACA (?)	Benthic and pelagic	Relatively shallow lakes in basins of low relief (small volume fluctuations or tilting produce great changes in area)
Long coastline with large, ecologically isolated stretches	BAIKAL TANGANYIKA NYASA	Benthic	Large elongate lakes

The restricted distribution of other species of gammărids, not so correlated with the present configuration of the lake basin, is explicable on the assumption of a single complete barrier effective in the geologically recent past. A partial barrier now exists on the site of the postulated complete barrier.

The intralacustrine distribution of not a single species flock of the African rift lakes, Tanganyika and Nyasa, is known. However, a consideration of the configuration of the basins of these lakes makes evident the possibility that intralacustrine geographical isolation has been responsible for the development of species flocks in these lakes as well as in Baikal.

The geographical features involved in speciation in Victoria Nyanza are entirely different from those effective in the lakes previously discussed. Similar features may have been responsible for some of the speciation in Lake Titicaca.

No information is available concerning the geographical features which may have been involved in the formation of the species flocks of the smaller lakes, Ochrid and Lanao.

The isolated group of lakes of the Malili River system in the Celebes presents a geographical situation for the development of species flocks which is fundamentally different from that found in any of the single lake basins.

Table 12 summarizes the types of intralacustrine geographical barriers and their apparent influence on species formation in ancient lakes.

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PERSPECTIVES IN THE FIELD OF MORPHOGENESIS

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This article contains essentially the text of an address on "The Outlook in Morphogenesis" delivered by the author at the International Symposium on Morphogenesis held under the auspices of the Centre National de la Recherche Scientifique in Strasbourg in July 1949. A French abstract will appear in the Proceedings of the Symposium. Having the character of an essay, this paper does not aim to "cover" any particular ground. Topics and examples have been chosen for illustrative expediency, rather than on absolute merit. Citations of literature are confined, as far as possible, to recent reviews and monographs, and original articles are quoted only when special documentation appears to be particularly pertinent.

INTRODUCTION

MORPHOGENESIS is once more coming to the forefront of biological interest, and its future becomes of immediate concern not only to biology, but to medicine and agriculture as well. Progress in the field is vigorous and rapid, and although we cannot foresee whither it will lead us, we can tell by extrapolating from present trends the direction in which it is heading. The advance follows two main currents, the one aiming at the accumulation and analysis of data, and the other at the clarification of concepts. Morphogenesis is still in the transition phase from descriptive "natural history" to analytical science. In this transition, techniques have somewhat outdistanced concepts. Many of us use modern physical and chemical tools of great precision, but by applying them to problems formulated in the much less precise phraseology of an outdated era, we often end up with results that are equally unprecise and ambiguous.

It is necessary, therefore, to bring our problems up to date. Considering their complexity, this is no easy task. There are tendencies to circumvent the difficulty by arbitrarily divesting the problems of their natural complexity. Then, operating with these oversimplified constructs, which barely resemble the real phenomena, one is apt to arrive at conclusions that are equally far from reality. To those with a firsthand acquaintance with the facts, the oversimplified, often factitious and synthetic notions of growth and differentiation, which seem to guide some current applications of biophysics and biochemistry to problems of morphogenesis, appear remarkably unrealistic. The use of ambitious but loose terms such as "chemical organizers," "growth substances," "differentiation hormones," "embryonizing effects," and so forth, has become a common occurrence. Cancer research is bringing into the study of morphogenesis recruits in increasing numbers. Many of them innocently fall for such catchwords, laboring under the illusion that they are heading for key solutions to the riddles of development. They would gladly redirect their efforts if those closer to the facts were to give them more correct and more precise information as to just where the real problems lie and how they look in reality. To give a single example, it seems to me utterly misleading to continue to represent to the outsider "the induction of the nervous system" or "the action of the organizer" as if they were simple, single, unitary, and elemental processes, now that we have definitely established that they are not. One could enumerate a substantial list of similar misrepresentations which in the long run hamper progress because they obscure the issues which they purport to clarify.

To be sure, impressive progress is being made despite the traditional muddle in our concepts. This is due partly to the fact that those familiar with the phenomena have mentally outgrown the old-fashioned concepts and have made the proper adjustments and rectifications in their own minds as they went along, without making this explicit to the "outsiders." For instance, most of those who have thoughtfully worked on amphibian development will readily admit that the term "organizer," which they use as a shorthand label for a known phenomenon, certainly does not deserve the universal connotation originally attached to it, of being the master principle of embryonic organization. However, those unfamiliar with the background and evolution of the problem misconstrue the term in just this sense and are accordingly misdirected in their thinking and even in their experimentation.

There can be no question but that the early boom of work on the "organizer" arose largely from the belief, or at least the hope, that it would bring a fundamental solution of the problem of embryonic organization. The very choice of the term bears this out. Serious arguments were voiced to discourage trust in a single and elementary solution of the problems of embryonic determination (Harrison, 1933; Weiss, 1935), and indeed, further work disproved the original one-sided connotation. The term "organizer" thus turned out to be a misnomer (Weiss, 1939a), yet, although this has been clearly recognized by many, including its originator, Spemann (1939, p. 367), common usage will not easily discard it in favor of a more pertinent and less pretentious term.

The situation in morphogenesis is not unlike that in gunnery. Even with the most perfect barrel and firing mechanism, hits will be few if the target either is blurred or moves around erratically. Therefore, future progress in the study of morphogenesis will depend significantly on whether or not we shall succeed in emulating the exact sciences by clearly marking and steadying our targets; that is, by describing the phenomena, problems, and results in objective, concrete, and unambiguous terms and units.

FORM AS FORMATIVE PROCESS

The first task along this line is to translate the conventional terms of descriptive morphology, largely gained from plain observation, into what might be called "instrumental terms." We must form the habit, for instance, of viewing the shape of a given cell, tissue, or organ not as a static feature, but as a phase, transitory or terminal, in a continuous chain of transformations; as a cross section through a stream of processes proceeding in time. Every morphological criterion is but an expression of antecedent processes that have contributed to its formation. Distance, in this version, becomes an index of past attractions, separations, intercalations, etc.; shape, other than spherical, the result of distortions due to elongation, secretions, shifts, contractions, expansions, differential growth, and the like; coloration, the result of chemical transformations yielding end-products which reflect and absorb certain wave lengths of incident light, plus such factors as aid in the production, destruction, accumulation, or dispersion of those chemicals. This is a way of thinking which, when applied to even the simplest process of morphogenesis, immediately reveals our dearth of exact knowledge. How does a cell layer double over to form a fold? How does a cell cord (e.g., the epimere) become cut up into segments? Is a forked structure due to collateral budding or terminal fissure? Does a solid cell mass become hollow by secretion, by cell resorption, or simply by elastic retraction? What are the differences, in terms of the underlying engineering processes, between a straight and a spiral tube, between a smooth and a corrugated surface, between anastomosing and blind arborizations? Innumerable such questions will have to be answered before we can turn our full attention to the broader issue of why things happen as they do.

The same need for more pertinent and precise description applies to the traditional concept of the cell. While cytochemistry, on the one hand, is bringing forth a wealth of detailed information (see Lison, 1936; Hoerr, 1943; Brachet 1945), common usage in embryology still has the cell "do" this or that, draws over-all balances of its activities and, in general, treats it as an elementary unit, overlooking its enormous inner diversity, heterogeneity, and variability. Although we acknowledge the existence of morphological subdivisions, such as the nucleus, nucleolus, cytoplasmic inclusions, mitochondria, and a membrane, we leave the matrix of the system, the so-called protoplasm, essentially unresolved. We generally concede to it "organization," but remain noncommittal as to the precise implications of this term. To the microscopist, whether he uses visible light or electron beams, protoplasm appears to possess a static mechanical framework as backbone of its organization. To the general physiologist, it is often no more than a colloidal solution contained in a more rigid membranous bag. The former view is hard to maintain in view of the great mobility of the cell content, while the latter view, of course, fails to explain how the orderly spatial segregation of the various disparate cell activities can be maintained without an underlying framework. We are faced here with an historical, but as yet unresolved dilemma. And since growth is essentially an increase in protoplasm, and differentiation a transformation of protoplasm, better insight into the nature of protoplasmic organization is prerequisite for the understanding of morphogenesis (see Seifriz, 1942).

MOLECULAR ECOLOGY

Mindful of this state of affairs, I have in recent years tried to sketch a concept of protoplasm which, however imperfect it may be, at least tries to present the cell in a more realistic and less symbolic light than before, and at the same time lends itself to experimental verification. This concept portrays the cell as a complex population of interdependent molecules and molecular complexes, whose behavior depends on the local physical and chemical conditions prevailing in the space which they come to occupy. These conditions assume the presence of an organized and relatively invariant pattern along all existing interfaces, such as the cell surfaces, nuclear surfaces, chromosome surfaces, surfaces of filamentous and globular cell inclusions, and so on, and this over-all order of conditions produces, preserves, and after disturbance restores the typical heterogeneous distribution of the various molecular species, despite their high degree of mobility. Since this concept of a "molecular ecology" of the cell has been treated more fully on previous occasions (Weiss, 1947; 1949a; 1949b), it may suffice here to quote the following summarizing statements.

> "Each cell and organized cell part (nucleus, chromosome, etc.) consists of an array of molecular species whose densities, distribution, arrangement and groupings are determined by their mutual dependencies and interactions, as well as by the physical conditions of the space they occupy. These species range from the elementary inorganic compounds to the most complex 'key' species characteristic of a given cell. Chemical segregation and localization within the cell result from free molecular interplay, as only groups of elements compatible with one another and with their environment can form durable unions. The behavior of both developing and mature cells, as well as their restitution and regulation after disturbance, are faithfully described by this concept. . . . Among the principal segregative factors of molecular mixtures are interfaces. Interfacial forces between partly immiscible molecular populations concentrate certain selected molecular species of the interior along the border. By their surface positions, these border species acquire power over the further behavior of the enclosed system. This is due partly to their common orientation relative to the interface, which increases their structural coherence and chemical combining faculty, and partly to their control over substance exchange across the border. Various considerations suggest that in biological systems the fixation of a given molecular species in a surface is not due solely to unspecific factors such as surface tensions, adsorptions, etc., but that in addition, highly selective chemical affinities are involved. These may be based on the steric interlocking of characteristically shaped end groups of the surface molecules of adjacent systems." (Weiss, 1949b, p. 476).

I note that the concept of "molecular ecology" has found favor with some highly competent students of cellular biology (Monod, 1947; Lwoff, 1949, 1950; Schmitt, 1949). This seems to confirm its pragmatic value. Whether it will prove adequate, only the future can tell. Its main merit for the moment is that it presents us with a workable model of the cell by which the problems can be stated with greater precision; it helps us "focus our target."

One of its immediate effects is to show us a way of bridging the gap between chemical action and physical structure. Morphogenesis is the development of structures in space. Modification of morphogenesis by chemical agents has become a fruitful field of investigation (cf. Child, 1941; Needham, 1942; Lehmann, 1945). But while the effects of chemicals on some physical properties of protoplasm such as viscosity, fiber formation, cohesion, adhesion, etc., have been demonstrated, an exact knowledge of just how chemical action can produce or modify physical structures in such specific ways as are displayed in morphogenesis is still wanting. Here the concept of molecular ecology promises to furnish one of the missing links. For details, however, we must refer to the previous publications and some further comments made later in this article.

From these more general remarks let us now turn to the consideration of a few of the key problems in morphogenesis to see where some future advances have either already been inaugurated or can at least be reasonably expected. We shall single out for brief comment aspects of differentiation, growth, histogenesis, regulation, induction, and cellular reproduction, realizing the non-representative character of our arbitrary selection.

DIFFERENTIATION AND ITS CRITERIA

As I have pointed out on an earlier occasion (Weiss, 1949a), we must clearly distinguish between the process of differentiation on the one hand, and its visible criteria on the other. Most of the morphological criteria of cells and tissues usually described as "differentiations," as for instance contractile fibrils, pigment granules, secretion bodies, etc., are end products, hence indicators, of cellular manufacturing processes. Different end products indicate differences in their respective formative mechanisms. Such differences may be due to intrinsic differences in the constitution of the cells involved or to differences in the cellular environments. The critical test lies in transferring such cells to a common environment (e.g., tissue culture) whereupon, in the former case, they retain their distinctions, while in the latter case, they revert to a common type.

It has been found convenient to confine the term "differentiation" to the appearance of intrinsic and irreversible differentials among cell strains, in contradistinction to the varying and often reversible expressions which cells assume in response to different environments, and which have been termed "modulation" (Weiss, 1939a). In studying experimentally the case for and against true differentiations in this restricted sense, it has definitely been established that they are the rule in the various tissues of all mature higher animals. It has also been proven by the evidence of experimental embryology that the constitutional differentials among cell strains arise progressively during ontogeny. Cell strains from the same source and originally of identical character gradually assume divergent characters.

The diagram, Fig. 1, represents this situation in schematic form. It shows how cells of equivalent constitution derived from the same germ layer give rise to cell strains which have acquired different properties. These strains continue to dichotomize into further subdivisions until in the end the various specialized cell forms of the mature body appear. However, in the transition stages, as well as in the terminal stages, each cell is still capable of undergoing a variety of adaptive modulations in the course of which descendants of widely differing types may assume some morphological and physiological resemblance, without losing their type specificities. An example is the formation of phagocytic cell forms of the appearance and functional characteristics of macrophages (histiocytes), which can be obtained from muscle (Chèvremont, 1945), connective tissue (Bloom, 1937), glia cells (Weiss, 1944a), sheath cells of nerve (Weiss and Wang, 1945), yolk sac epithelium (Thomas, 1937), and perhaps still other tissues. The main point to remember is that in spite of assuming certain common functional aspects, the derivatives of these various

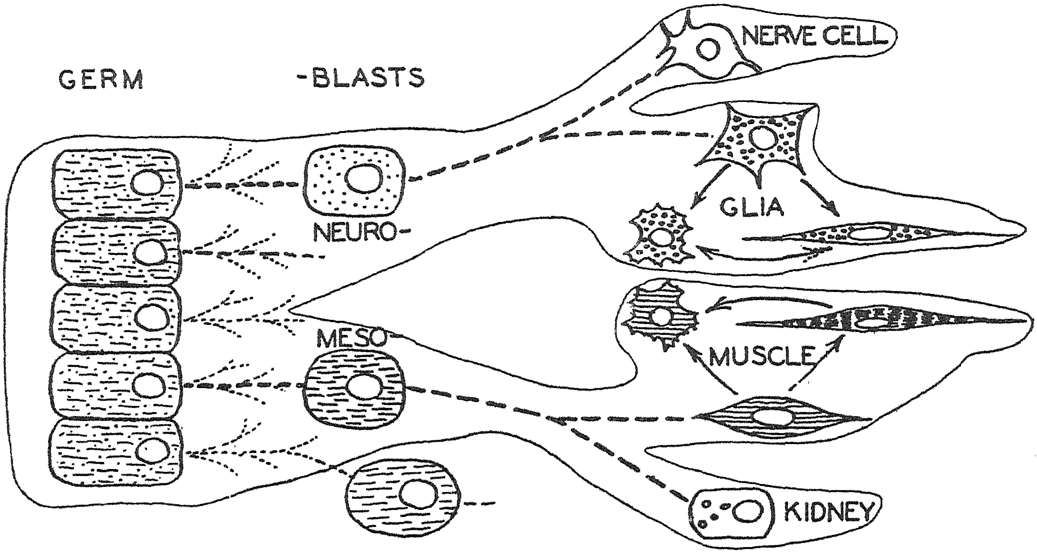

FIG. 1. DIFFERENTIATION OF FOUR CELL STRAINS, SOME WITH MODULATIONS INTO PHAGOCYTES

strains also retain some marked distinctions as indelible traces of their past ontogenetic differentiation.

In assessing the case for true differentiation, the mere retention of different specialized equipments in the very cells that were transferred to a common environment would not be crucial, for this could be ascribed to structural inertia. What makes the case conclusive is the fact that those cells proliferate many generations of new cells, and that these descendants, even though remaining in the common environment, continue indefinitely to carry the earmarks of their respective strains (Bloom, 1937, Thomas, 1938). While the occurrence of irreversible differentiation is thus an incontrovertible fact, the extent to which it occurs is an empirical problem, which has to be answered for each given case separately. The wide limits within which cell varieties of the mesenchyme, for instance, can still transform into one another marks them as modulations rather than subdifferentiations. This is strikingly corroborated by the study of regeneration in amphibians, in which the blastema cells derived from various mesodermal tissues of a given organ are equipotential (see Weiss, 1930). Those from a limb can produce all the mesodermal parts of a new limb, but not, for instance, of a new tail (Polejaiev, 1936), tail and limb mesenchyme as such being presumably true differentiations (contrary to earlier indications, Weiss, 1927; see Weiss, 1939a, p. 477). Recently, the startling claim has been advanced that most of the cells of a limb-regenerate spring from the epidermis (Rose, 1948). This would imply that adult epidermal cells after "dedifferentiation" give rise to muscle and cartilage. That the epidermis exerts some essential influence in the regeneration process has been known (Polezajew and Faworina, 1935); that some of its cells may escape into the blastema is quite credible; but from this to the assertion that they actually take part in the formation of the deeper limb tissues is a rather broad jump. Since this assertion is based solely on unconvincing observations and crude calculations, without crucial experimental support, it can hardly stand up in the face of overwhelming experimental evidence to the contrary, some of it (Hertwig, 1927), in fact, unreservedly quoted by Rose himself. It would take more convincing evidence to supersede the well-founded thesis that the various differentiated cell strains of the mature body are no longer equipotential and omnipotent.

By all judicious accounts, differentiation implies irreversible change. What remains to be determined is which part of the cell, or rather which fractions of its molecular population become transformed in the gradual process of specialization, and what other parts are exempted and persist in their primordial stage. We shall return to this point further below.

One of the difficulties with which we are faced in the study of cellular differentiation is the lack of more pertinent criteria than those furnished by mere morphological observation. Morphological criteria are incomplete, too late of appearance, and actually deceptive through their failure to reveal basic constitutional differences among morphologically similar cells. If drugs, hormones, radiations, viruses, etc., after general application affect certain cells to the exclusion of others, this proves the existence of differential susceptibilities and selectivities in the responding cells for which we have as yet found no other measure than just that differential response to the agent. Pharmacology offers numerous examples of a given drug or hormone affecting one portion of the vascular system quite differently from another, or singling out one nerve center from others, or one type or area of connective tissue in contrast to another. These physiological distinctions constitute valid proof that the body contains a much greater variety of differentiations than can be discerned morphologically. The same conclusion must be drawn from the following facts. Different areas of epidermis in the fowl respond to stimuli from the same papilla by forming different types of feathers (Wang, 1943). Different parts of the vascular tree are intrinsically different in their characteristic growth patterns (Scharrer, 1940). Different parts of the epithelia of the reproductive tract respond differentially to hormones (Moore, 1944). Each muscle possesses a biochemical sign distinguishing it from all other non-homologous muscles (Weiss, 1936). All of these signify basic differences in the respective tissues which could not be discerned by microscopic inspection. The list could, of course, be greatly expanded.

The same reasoning applies to the developmental history of differentiation. The crucial test of differentiation is not different morphological appearance but differential behavior based on differential constitution. Eventually such behavior may lead to morphological distinctions, but if so, it precedes them. Therefore, all morphological distinctions are antedated by premorphological distinctions, the demonstration of which calls for discriminatory tests by other than morphological techniques. One such test is implicit in Waddington's (1932) concept of "competence." This term refers to the fact that cells change their response patterns during development without expressing this change by convenient external signs. On the thesis that differences in response (under otherwise comparable conditions) must be based on differences of material constitution, deduced changes in "competence" may be regarded as a natural corollary and index of progressive premorphological differentiation.

PREMORPHOLOGICAL DIFFERENTIATION

Although the day seems still pretty far off when it will be possible to gauge and describe a given cell stage in terms of its actual properties, rather than indirectly by assaying developmental responses, certain hopeful approaches are opening up. One approach lies in tracing the developmental history of specific proteins that appear in the course of cellular differentiation. In first approximation, this can be done by determining the emergence of known proteins, such as myosin (Herrmann and Nicholas, 1948) or defined enzymes (Flexner, 1946, 1948; Boell, 1948; Holter, 1949). For purposes of differential diagnosis of cell differentiation, however, one would have to design much more refined cytochemical methods than are currently available. A more indirect way lies in the identification of proteins and protein differentials by their specific antibodies. Immune reactions to specific organ extracts can in many cases be demonstrated by the selective response of the homologous organs to the corresponding antibodies (Loeb, 1945; Landsteiner, 1946). Some years ago we started experiments to test the possible effect on embryonic organ growth of injected antibodies against the homologous organs (liver, kidney, and muscle in the chick). The results suggested the existence of a specific effect (Weiss, 1947), but they are in need of repetition and extension, and particularly the discriminative sharpness of the specificities involved remains to be demonstrated (Irwin, 1949). Research along similar lines has since been taken up by other laboratories (Pomerat, 1949; Grunwaldt, 1949).

We have continued the experiments recently in combination with radioactive tracers (jointly with D. H. Campbell). This was done by building a C_{14} chain into the organ-antibodies and then injecting the tagged material into the yolk of developing chick eggs. Any accumulation of the tagged material in the homologous organs would be evidence of selective absorption. Prior tets with C_{14}-tagged glycine injected into the yolk (jointly with J. W. Saunders and H. Holtzer) had shown ready accumulation of the active compounds in the embryonic tissues, and hence proved the feasibility of the method. Unfortunately, the tagged antibody preparations up to now have not had both a sufficiently high immune titer and a sufficiently high radioactivity to produce conclusive results.

By some such technique it might be possible to trace back organ specificity into its embryonic history and to reconstruct an "ontogenetic tree" of differentiations, much as phylogenetic relations have been established by serological tests (see Boyden, 1942).

Another technique of tracking down biochemical ontogeny lies in the application to the embryo of chemical agents with known organ- or tissue-specific effects in the adult. As a first test, we have injected xanthopterin into chick embryos, since this drug has been reported (Haddow) to have a selective stimulating effect on mitotic activity in the kidney of the adult mouse (in addition to general hematopoietic effects). The point was to investigate how early in development such an effect on the kidney or the kidney precursors in the embryo could be demonstrated (M. W. Cavanaugh, collaborating). Thus far, we have been able to show no other than toxic effects on the embryonic kidney, either when applied to the embryo itself or to embryonic tissue cultures containing xanthopterin (kindly supplied by Dr. Haddow, London). However, with the rapid growth of chemotherapeutical research, an infinite number of similar tests could be devised (e.g., possible effects of triazin on embryonic intestine), and work in this direction would seem well invested. Another lead worth investigating would be detection of incipient differences in embryonic tissues with respect to compounds that happen to be accessory growth factors for mutant strains of bacteria or fungi and, therefore, could be assayed by the addition of their extracts to deficient growth media.

For earlier stages of development, the splendid analysis of the differential action on different parts of the developing egg or embryo of specified chemicals, such as lithium, sulfocyanate, amino acids, etc. (Lehmann, 1945; Hörstadius, 1949; Ranzi, 1949; Lindahl, 1942), have brought us nearer an understanding of their mechanism of action. When properly evaluated, the results of this "chemical teratology" belong rightfully in the category of differentiation tests here advocated, since they not only expose, but actually identify, latent differences in protoplasm which are of developmental significance.

AFFINITIVE RELATIONS ("COAPTATION")

Although the physico-chemical detection of premorphological differentiation among cell strains is thus still largely a matter of the future, one discriminative biological test is already at hand, and that is the capacity of the cells to tell each other apart according to their kinds. Thus we may use the cells themselves to do us a service which our analytical tools have not yet mastered. The model of this test lies in the classical experiments on dissociation and reassociation of coelenterates, hydroids, and sponges (see Brondsted, 1936). In those experiments, cells of a given kind were found to recombine with their own in preference to other kinds. The result is a self-sorting of cell types. The mechanism of selection does not seem to lie in specific attraction among homologous cells but rather in the fact that, upon making contact, matching combinations remain together while non-matching ones do not endure.

Similar affinities and disaffinities among cells of compatible or incompatible kinds have been described by Holtfreter (1939) in the early development of amphibians, the only difference being that in his cases cell groups rather than individual cells constituted the discriminative units. Cell groups which at an earlier stage are compatible gradually develop mutual incompatibility leading to segregation. This is clear evidence of a true biochemical divergence in the respective cell lines, hence of premorphological differentiation. In expanded form, this concept has, as I have tried to demonstrate (Weiss, 1947), fundamental implications for morphogenesis. It seems that cells, as a corollary of their differentiation, develop surface constitutions which render them adhesive to surfaces of the same or of fittingly complementary constitution, but unfit for association with non-conforming types. All during ontogeny cells and cell groups undergo extensive shifts, which bring about major changes of position, and hence, of mutual relations. During the resulting recombinations, permanent unions seem to be initiated by the active surface bonding of matching cell types, rather than by sheer mechanical cementing. In order to become settled, a cell must be fully adjusted and equilibrated with the conditions prevailing along its various surfaces, including its neighbors of the same kind, adjacent cell layers, the intercellular matrix, and the liquid media bathing its free portion. This relation may be designated as "coaptation."

Coaptive relations are outlined diagrammatically in Fig. 2. The top strip shows an epithelium whose cells A are adjusted to lateral association with similar cells A, to basal association with a cell type C, and to exposure to a medium B. The arrows at the right indicate compatible combinations in solid lines; incompatible ones in broken lines. The middle strip illustrates the unbalancing of the cell in consequence of a change of medium B to B′. The outer surfaces become unstable, and such cells may become motile. The same occurs when the lateral association among cells of the type A in a layer is severed so that a surface formerly bordering on A becomes exposed to a medium B. This is the case after injury, and it explains the automatic mobilization of the cells along the border of a wound, which is the primary response in wound healing. Evidently, any cells with unsaturated lateral "valencies" will keep on the move until they are completely surrounded by cells of their own or a related kind, when the condition of coaptive stability has again become satisfied. The mechanism that sets cells in motion at the beginning of wound healing and stops them again after its completion thus appears to be merely a special case of the more general principle of selectivity in cell association and dissociation.

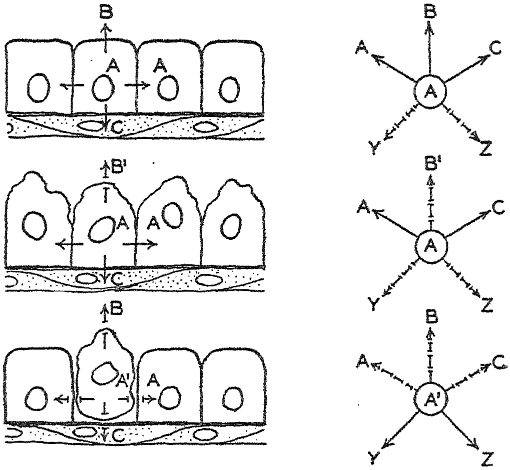

FIG. 2. AFFINITY RELATIONS IN EPITHELIUM (LEFT) WITH RELATION DIAGRAMS (RIGHT)

Full arrows indicate conformance of conditions (active "bonds"); interrupted arrows, non-conformance.

The bottom strip of the diagram finally shows what may happen when one cell of a group becomes altered internally, for instance, as a result of somatic mutation. In changing from A to A′, it loses coaptation with all surrounding systems A, B, and C, and isolates itself or is expelled. As is indicated in the relations diagram on the right, loss of affinity to A, B, and C could conceivably be accompanied by an increase in tolerance for less specific conditions Y and Z, which would allow the cell to survive under conditions under which it could formerly not have persisted. Formally, this depicts the behavior of cancer cells, particularly their estrangement from the mother tissue, invasiveness into other tissues, and capacity to become lodged in atypical locations. However, to fill this formal picture with factual content remains a task for the future.

The subtle means by which cells can recognize each other and their appropriate environments are still wholly conjectural. That their methods of identification are sharply discriminative can be demonstrated by bringing them together in atypical combinations. We have started a systematic investigation of this phenomenon (jointly with J. Chiakulas) by (a) interplanting fragments from various differentiated tissues of the amphibian larva in the gelatinous tail fin, which furnishes a vascularized, but otherwise rather neutral, testing ground; and (b) grafting patches of various epithelia (gut, cloaca, lung, etc.) into skin defects. Left to itself, a given tissue fragment (liver, pancreas, cartilage, kidney, etc.) readily fuses intimately with any other fragment of the same or of a related type, but retains a demarcation line against unrelated types.

I have tentatively suggested that the specific "recognition" may consist of the formation along the cell surfaces of specific stereochemical bonds between matching macromolecules in adjacent cells, comparable to the interlocking of antibody-antigen systems (Weiss, 1941, 1947). Whether the specific surface action is exercised by the outermost layer of the cytoplasm itself or by some film of specific exudate which no longer forms part of the living system, makes little difference in the present context. Yet, it is noteworthy that cells quite commonly exude macromolecular films which have important effects on cell behavior (Friedenwald, Buschke, and Crowell, 1945; Weiss, 1945), which have been suggested as intermediary binding agents between cells (Chambers, 1940; Schmitt, 1941), and which have been shown in protozoan cells to be the seat of serological reactions (Harrison and Fowler, 1946). The problem is somewhat complicated by the fact that the primary adhesive forces are secondarily reinforced and perhaps fully supplanted by intercellular fiber cements. Calcium seems to be an important factor in this process (Coman, 1944), but can obviously not account for the selectivity of the bonding.

It must be kept in mind that coaptation implies not only molecular surface conformance but also harmony with all mechanical and physiological manifestations of the surrounding cellular and non-cellular systems.

CONTACT REACTIONS

Once again, we are made to realize the necessity of revising the conventional concept of the cell in morphogenesis by giving the physical aspects of molecular behavior greater prominence. Those who accepted the cell as a relatively uniform elementary unit naturally came to regard chemical effects mainly in stoichiometric terms, that is, with the emphasis on composition, dosages, concentrations, and rates, but with little regard to spatial micro-organization. However, as soon as the picture of the cellular unit is resolved into that of a highly organized population of interacting molecules and molecular aggregates, stereochemical properties, molecular structure, shape, orientation, alignment and, more generally, physical order, assume decisive significance in the determination of biological events. The concept of molecular ecology embodies this change of emphasis, for it illustrates how interfaces, by selectively adsorbing, orienting, and aligning molecular key species from the cellular content, produce the physical conditions of spatial order which enable stereochemically complementary compounds, such as antibody-antigen or enzyme-substrate systems, to interact most effectively. According to this concept, the following would happen when a cell comes into contact with another body whose surface is settled with molecules with specifically formed end groups oriented toward the oncoming cell. As the agitated molecular population of the moving cell passes in review, as it were, before the stable molecular front of the outer surface, molecules of conforming configuration will be trapped by their correspondingly shaped counterparts. Thus, a specific fraction of the cell content will gradually become concentrated and segregated along the contact surface. Since these surface molecules, by virtue of their orientation, might serve not only as anchor points for the adsorption of additional molecules from the interior, but also perhaps as specific catalysts of reactions inside the cell, a whole train of events determining the further chemical history of the cell has thus been set into motion. It can readily be seen that the chemical fate of a cell on contact with another does not depend merely on what substances are present in it, but also on the strategic advantages given to one or another segment of the molecular population according to the chemical character of the contact surface.

This condition is illustrated diagrammatically in Fig. 3, which shows two epithelial cells in three consecutive stages. Large molecules with specific end groups are indicated by various symbols. In the initial stage, both the upper and lower cells have identical chemical endowments (lefthand diagrams). Now let us assume that the upper cell makes contact with a system containing in its surface oriented molecules with arrow-shaped heads, while the lower cell confronts a surface with molecules with cup-shaped ends (middle diagrams). As a result, in the upper cell, the notch-shaped molecules will be trapped and fixed, and in the lower one, the ball-shaped ones,—in either case, those of the most nearly conforming configuration. As one can see, the chemical composition of the two cells is still the same, but a segregation process has been initiated which is different in the two and, if allowed to continue, will in consequence lead to an increasing internal diversification. This is indicated in the righthand diagrams, in which each cell is shown to have added a second macromolecular layer of fitting configuration to the first. As entirely different chains of chemical reactions are thus set going in the two cells, it will not be long until the composition of their contents will have become radically different; each will develop certain compounds not present in the other. The eventual consolidation (righthand diagram) is irreversible and represents what we have called cellular differentiation, while the transition stage (middle diagrams) is still reversible, representing mere modulation. Permanent differentiation can, therefore, be regarded as merely an advanced stage of an initially reversible modulation.

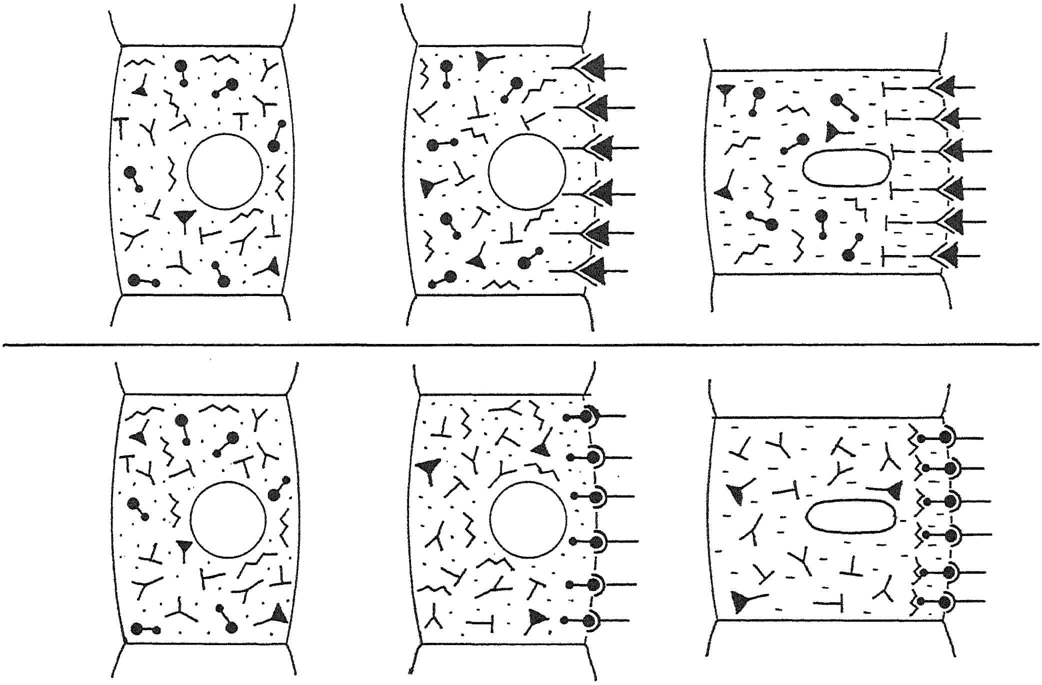

FIG. 3. MOLECULAR REARRANGEMENTS UPON CONTACT WITH DIFFERENT ORGANIC SURFACES: A MODEL OF INDUCTION

Since my presentation of this concept of the molecular basis of differentiation at the Growth Symposium in 1945 (Weiss, 1947) and again at the Princeton Bicentennial Conference in 1947 (Weiss, 1949a), Spiegelmann (1948) has set forth some thoughts that, although making no explicit reference to our views, implement them in several points.

INDUCTION

It will be immediately recognized that the above diagram gives a pertinent illustration of those specific influences of one tissue on an adjacent one, commonly referred to as "inductions." The most frequently cited examples are the effect of the chorda-mesoderm upon the overlying ectoderm in calling forth the formation of a neural plate, and the induction of lens in the epidermis overlying the eye vesicle (Spemann, 1938). It has long been known that under natural conditions such inductions take place only if the inducing and induced layers are in close contact. Interposition of a narrow gap or a thin layer of some other tissue abolishes the effect (Dragomirow, 1929; Holtfreter, 1933). However, no systematic study has been accorded this subject. In observations on the finer histological changes attending lens induction in the chick, I noticed some years ago that at the time of contact between the eye vesicle and the ectoderm, the cells of the latter become elongated and oriented in the direction of the subjacent retinal cells (see Weiss, 1949b, p. 478). Their nuclei assume a rod shape and move to the border of contact (Fig. 4). These changes are now being studied more closely (in collaboration with M. McKeehan). The phenomenon of orientation seems to be exactly coextensive with the area of intimate contact. It lasts only for the few hours known to be the crucial and critical time for lens induction (Fig. 5). At the same time, the cells of the lens ectoderm become so firmly fused to those of the retina within the contact area that the two layers cannot be separated (also observed casually by Stone and Dinnean, 1940). Thus, we have evidence that the contact produces an intimate association between the two cell types followed by an oriented reorganization of the presumptive lens plate in relation to the more advanced and consolidated retinal plate—just the type of changes to be expected in terms of the above concept. Having gone through this critical surface reorganization, the induced layer becomes detached and can then continue independently with the next step in the formation of a lens vesicle. If it had been faced with another tissue than eye cup, some other segment of the molecular population would have been segregated in the surface, yielding another type of differentiation, always within the limitations of the molecular equipment ("competence") available in the cell at that particular time.

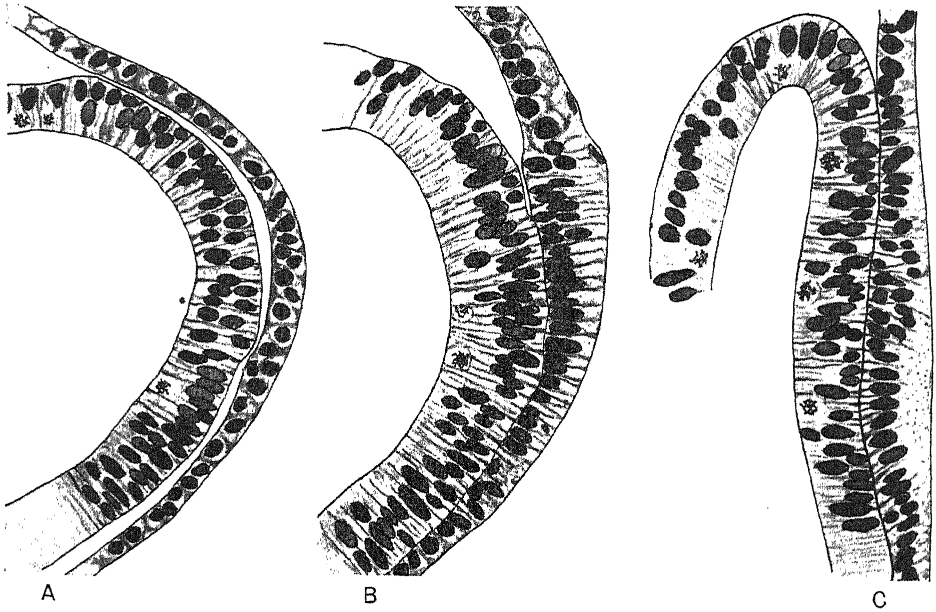

FIG. 4. CELLULAR CHANGES DURING LENS INDUCTION

A, Preinduction stage (ca. 14 somites): contact between retina and epidermis about to be effected; epidermal cells unoriented. B, Height of induction stage (19 somites): cells within contact area oriented towards retina; nuclei near basal pole. C, Postinduction stage (21 somites): early self-differentiation phase, with beginning concavity of lens placode and concomitant reorientation of lens cells radially.

Cell elongation and nuclear orientation are regarded here as due to an oriented reorganization of cell components in the direction of the contact surface rather than to an increased lateral attraction between neighboring cells, which has been suggested as the mechanism of neurulation by Brown, Hamburger, and Schmitt (1941). The

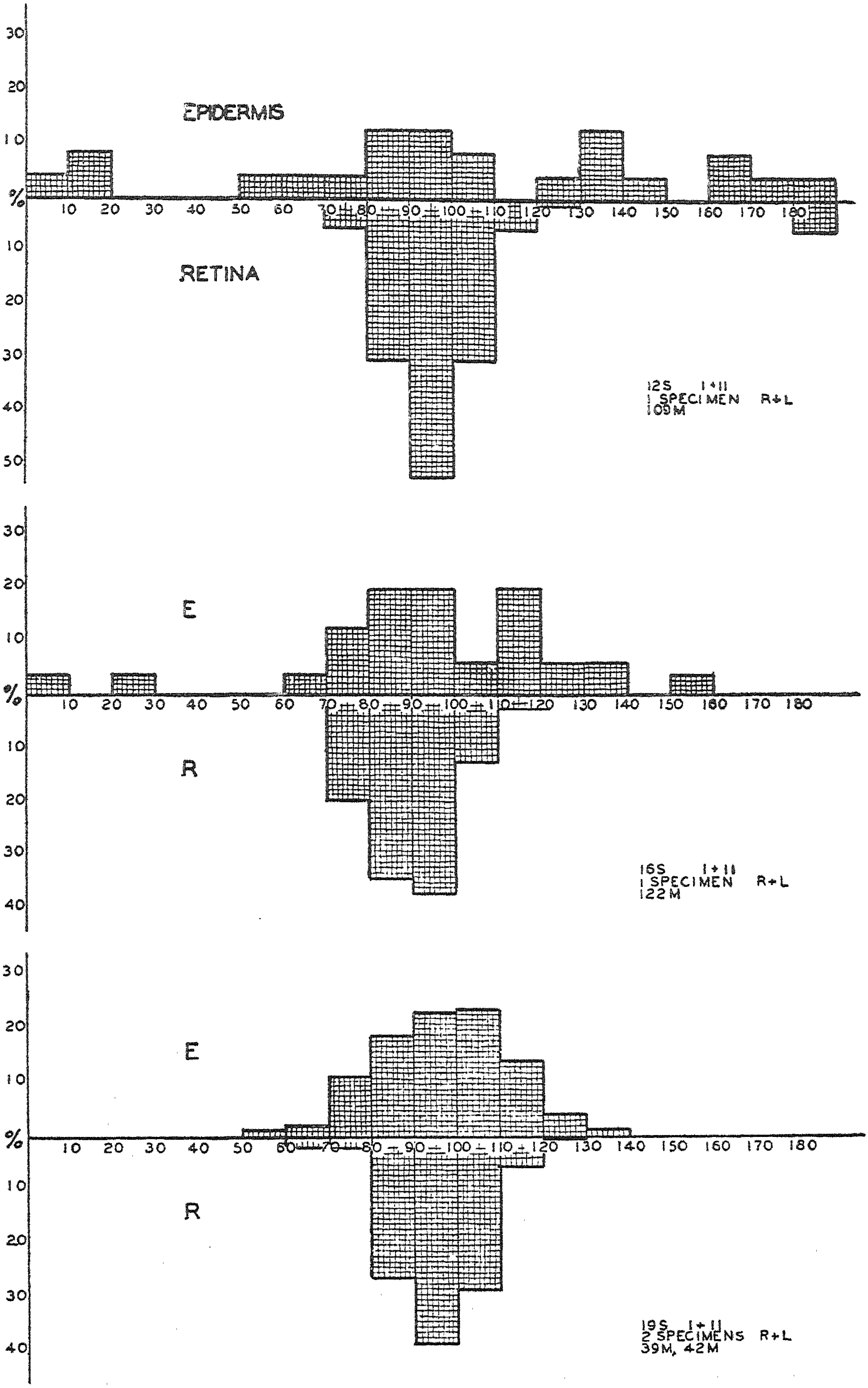

FIG. 5. STATISTICAL EVIDENCE OF ORIENTATION EFFECT ILLUSTRATED IN FIG. 4

The axes of the cell nuclei in retina and overlying epidermis were traced. The angles between these axes and the retinal surface were measured. The percentage frequencies of the various positions (in classes of 10°) were then plotted, downward for retina, upward for epidermis. Peak frequencies at 90° indicate perpendicular orientation. Top: 12-somite stage. Middle: 16 somites. Bottom: 19 somites. The progressive orientation of the epidermis relative to the retina from top to bottom is evident. (From unpublished data of M. McKeehan.)

correlation between diffusion lines and microstructure observed by Pollister (1941) in mature cells gives indirect support to our interpretation. Marked orientation of cells ("palisading") as an early symptom of induction has been reported incidentally by several authors without further comment (e.g., Lehmann, 1929; Holtfreter, 1933). It is common in many pathological transformations (e.g., tumors), and we have also observed it in the skins of amphibian larvae over topically applied crystals of the carcinogen, methylcholanthrene (Overton, 1948). A closer cytological and physicochemical analysis of the phenomenon of palisading, with particular attention to such signs of molecular regrouping as stratification, orientation of fibrous elements, etc., therefore promises to yield valuable clues as to the mechanism of inductive contact interaction.

According to the hypothesis here proposed, the inductive effect of one cell upon another and the selective adhesion (contact affinity) between two cells would have a common denominator, namely, the formation of linkages between matching molecules across the contiguous cell surfaces. Each patch of interlocked key molecules along the interface would then become an anchor point for bundles of molecular chains extending into the interior of both adjoining cells. Morphologically this would look like fibrillar continuity. On the molecular level, however, this would merely mean continuity of axial orientation among the chains on either side of the interface. This is a good example of how many of the microscopic arguments about contiguity vs. continuity among cells (e.g., neurons) lose their meaning when viewed in molecular dimensions.

Porter (1948) has recently produced electron-microscopic pictures of contiguous epithelial cells in which fibrillar strands can be seen to pass continuously from one to the other across the border. Although strains and stresses during histological fixation may have exaggerated it, the picture does suggest that orientation effects can be transmitted from one cell to another without the presence of "protoplasmic continuity" in the sense of the classical microscopist (see also the inductive transcellular orientation effects observed in plants [e.g., Sinnott and Bloch, 1945; Gautheret, 1946]).

ASSIMILATIVE INDUCTIONS

One of the features complicating the study of embryonic induction is the fact that the response of induced tissue consists mostly of a complex chain of reactions which involves further inductive and segregative acts. Much clarification may, therefore, be expected from a study of more elementary and more uniform induction processes such as take place during later stages of development, particularly within a given tissue, as for instance, the induction of cartilage by cartilage. Nageotte (1922) was the first to show that even alcohol-fixed cartilage can still induce the formation of additional cartilaginous tissue in the ear of the rabbit. A further utilization of this method promises to reveal, at least for these cases, to what extent the specificity of an induction product is determined by the specificity of an inducing tissue on the one hand, and by the character of the responding cells on the other. This problem has received considerable clarification by the use of heteroplastic and non-living grafts as "inductors" (literature in Weiss, 1935), yet it would seem even easier of solution if simpler conditions were chosen. We have, therefore, extended the experiments of Nageotte on the inductive action of differentiated tissues after devitalization. Rapid deep freezing, followed by dehydration in vacuo at low temperature, has proved to conserve many properties of the living tissue (including enzyme activity and physical structure) more truly than most other methods of fixation (Hoerr, 1943; Boell, 1945). When cartilage treated in this manner was transplanted into the limbs of salamander larvae, it became partially resorbed, but the defect was then repaired by host cells which deposited new cartilage along the surface of the devitalized fragment (Weiss, 1944b; see 1949a, Pl. 2, p. 151), as bees would build on to an artificial honey comb. Similarly, frozen-dried cornea grafted into corneal defects in the eyes of rats and rabbits was seen to induce the formation of new corneal layers in the host tissue (Weiss and Taylor, 1944; Leopold and Adler, 1947). Evidently, specific effects of the grafts have stimulated the host tissues to homologous formations. Further experiments will have to decide whether or not this involves more than simply the activation of latent homologous cell reserves. The fact that dead graft and live host tissues have formed an organic union distinguishes these cases from induction by dead tissue obtained in the embryo, as in the latter the dead piece is not structurally adopted by the host.

There have been some interesting reports on bone induction in developed animals by alcohol-extracts of tissues (Levander, 1945; Bertelsen, 1944), but the specificity of these effects has been rightly questioned (Heinen, Dabbs, and Mason, 1949) and their interpretation is still in doubt.

The facts and ideas about induction presented above clearly militate against the opinion often expressed in current literature that induction is carried out by diffusing chemicals discharged from the inducing tissue, implying that physical conditions are of no particular relevance to the effect and, therefore, may be ignored. So long as the precise mode of operation of this class of inductions has not been identified, mere reference to the participation of "chemical agents" remains a platitude, and insistence on the diffusibility and stoichiometric character of their effects a gratuitous presumption. Even those inductions which have been obtained after immersion of a tissue into a supposedly structureless liquid might turn out to be mediated through a structured physical envelope of coagulated macromolecular matter liberated from damaged cells. Observations on the relation between cytolysis and induction (Holtfreter, 1948a) encourage such a view. Additional work is needed, however, to make the proof conclusive. In support of diffusible action, cases have been reported in which embryonic inductions evoked by organ extracts differed in character depending on the evoking agents (kidney or liver) (Toivonen, 1940). But this could also be explained in terms of differences in the reacting tissues. If, for instance, the rates of liberation, penetration, etc., of these two substances were different, such that one would affect the embryo at an earlier stage than the other, the responding cells, being in different stages of "competence," would naturally turn out different products (see also Holtfreter, 1934).

Moreover, in all such considerations, one must never lose sight of the fact that since in the past quite a variety of phenomena have been arbitrarily labeled as "inductions," it would be unreasonable to expect them to be all of a single kind, to have the same basic mechanism, or even to follow a common rule. We must be prepared to find "inductions" of many degrees of specificity and complexity, employing a great variety of mechanisms, in which physical factors and chemical agents participate in many sorts of combinations.

✓ PROTOPLASMIC REPRODUCTION

We have treated differentiation primarily under one aspect, namely, the appearance of differentials among cells that were originally alike. There remains another aspect to be considered, namely, the perpetuation of the differentiated state as a cell grows and reproduces. Differentiation is actually a property of the cell strain. An individual cell is but a sample taken from the protoplasmic time continuum of cell generations that lead from a blastomere to the mature stage. As it matures, this mass gradually evolves the inner diversity which we call differentiation. By successive cell divisions, the progressively transforming mass is subdivided, but the differentiated constitution—though not every differentiation product—is carried over directly from mother cell to daughter cells. Thus, no cell past the germ cell stage is ever in a strictly "undifferentiated" state.

Let us now assume for the moment that we had a complete molecular inventory of each cell, listing all the chemical compounds to be found in it, their relative concentrations, distributions, and arrangements in space. Let us then consider two cells of the same germ which have undergone some degree of differentiation, in divergent directions, and hence differ in their molecular populations; for example, a myoblast and a neuroblast (Fig. 1). Although descended from equipotential stock, these two cells are no longer equipotential. One can no longer be turned into the course of the other. Each propagates only its own kind, and in doing so, imparts its own specific character to its offspring. The lessons of tissue culture have demonstrated that the basic character of a cell acquired during ontogeny is faithfully reissued in all its progeny (see Bloom, 1937; Thomas, 1938). If this were merely a matter of a given store of equipment being distributed over the descendants, one would have to expect a progressive dilution or attenuation of the differentiated character in successive cell generations. Differentiated products, if not renewed, may suffer this fate (e.g., yolk platelets in the course of successive divisions of primordial blood cells; Cameron, 1941); but the basic differentiated protoplasm has never shown any sign of depletion so long as growth and proliferation continue. We must conclude, therefore, that as a daughter cell grows up to the size of its mother cell, it reproduces and multiplies the specific molecular population of the latter in essentially the same form in which it received it. Myoblasts reproduce myoplasm, and neuroblasts neuroplasm.

This raises a very interesting problem. According to current genetic opinion the chromosomal genome remains qualitatively the same for all cells throughout development (for some qualifications, see Huskins, 1947). All differentiated cell strains, therefore, are supposed to possess the same genome. Nevertheless, as just outlined, they breed true according to kind, not unlike so many different strains of protozoans. Are the two facts at variance?

In dealing with the relations between genetics and development, it is well to keep in mind that an organism is constituted like a system of Chinese boxes, in which larger ones enclose smaller ones in a descending series of magnitudes. This hierarchy of systems is indicated in Fig. 6. This diagram shows the gene as part of the chromosome, the chromosome as part of the nucleus, the nucleus enclosed in the cytoplasm, the cell as a whole enclosed in the tissue, and the latter again enclosed in the organism, which in turn is set off against the environment. Theoretically, any one of these systems can be affected only through the medium of the systems of the next higher and next lower orders. Each layer of the diagram, therefore, is potentially a filter and transformer for actions and agents that penetrate it. Some, like radiations, may pass through relatively unaltered, while others may be profoundly changed in transit. A chemical entering from the environment may react, hence be altered, in passing through the surface of the organism, again in the tissue juices, once more in the cytoplasm, again in passing through the nuclear space, and finally in the non-genic chromosome matrix, before it ever reaches a gene. Furthermore, as each one of the series of shells of this diagram must be viewed as a potential originator, as well as receiver, of actions relative to any and all of the other shells, we are confronted with a very complex

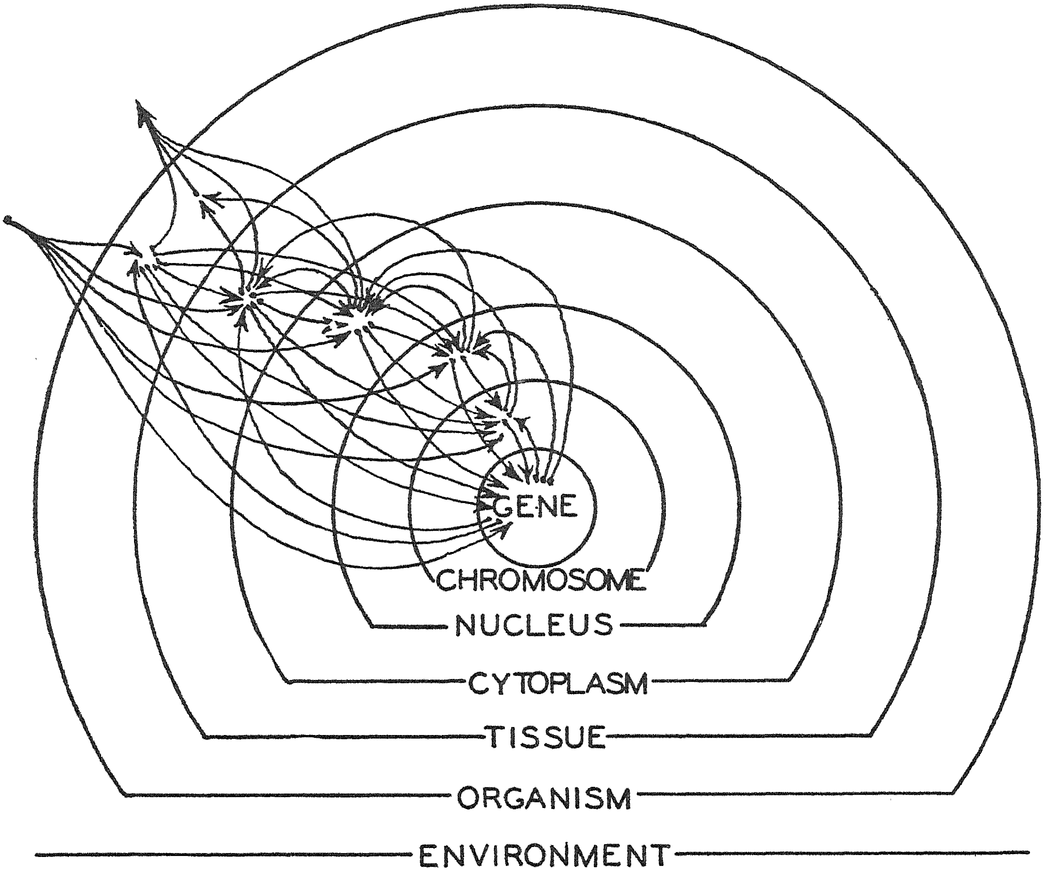

FIG. 6. RELATIONS DIAGRAM FOR HIERARCHICAL ORGANIZATION OF THE BODY

system of possible interactions, the intricacy of which is symbolized by the confusion of lines in the diagram. To bear this situation in mind will keep us on guard against oversimplified concepts regarding the directness of effects of "gene substances" on peripheral characters, and conversely, of peripherally applied substances upon genes.

Growth means the augmentation of protoplasm. Since this can occur only in the presence of an original protoplasmic model, we correctly speak of reproduction, rather than production. We know that the growth of the organism and of its tissues can take place only through the agency of its cells. Therefore, the mechanism of growth, as protoplasmic reproduction, must lie somewhere within the inner circles of our diagram. In order to reconcile the identity of the genic equipment (innermost circle) of all body cells with the specific self-reproduction of the various differentiated protoplasms, one has come to assume "self-reproducing" or "self-duplicating" units in the cytoplasm, which for obvious, though not necessarily valid, reasons are called plasmagenes. Combined evidence of morphological, physiological, biochemical, and genetic character, summarized in recent symposia (Sonneborn, 1947; Lwoff, 1949; Brachet, 1949) has made an impressive case for the existence of such self-reproducing cytoplasmic particles. Their potential significance for the problem of differentiation has also been properly recognized.

Yet, to charge the perpetuation of differentiation wholly to identifiable autonomous entities, set in opposition to an undifferentiated matrix, would seem to oversimplify the issue. Moreover, while it is conceivable that differentiation, like genic transmission, resides in discrete particles, we cannot be sure that the synthesis of the specific macromolecular compounds which make up these cytoplasmic particles actually takes place in the locations at which we find them, as is implied in the term "self-duplication." If this were true, growth would occur in innumerable small centers scattered throughout the cytoplasm. That this is not the case has been shown by some recent studies on the growth of the neurone.

In an extensive series of experiments, we have found that the enormously elongated cytoplasm of the axis cylinder does not contain its own sources of growth but that all growth comes solely from the nucleated territory in the central cell body (Weiss and Hiscoe, 1948). When the cross section of an axon is locally reduced by constriction the part lying distal to the bottleneck, that is, on the far side relative to the cell body containing the nucleus, remains undersized in proportion to the amount of constriction, while excess neuroplasm piles up at the proximal side of the narrow passage. In general terms, this bears out the contention of Caspersson and his school (see Hydén, 1943), according to which all specific protein synthesis takes place at the site of the nucleus. It goes beyond these views, however, in indicating that the nuclear products are already the real stuff of growth rather than merely catalytic agents which would then secondarily initiate and entertain local growth in the distant cytoplasm. Our results suggest that all protoplasmic systems that ever occur in the space of the cell must have been delivered originally from the nuclear space. On this basis, all protein systems and other complex protoplasmic systems found in the cytoplasm that are different from the primordial nuclear source products would have become so by processes of degradation and conversion from the primordial source products. In this light, the existence in the cytoplasm of sites of true protoplasmic synthesis becomes questionable, and one would have to turn to the following alternative view.

The basic protoplasmic units would be reproduced within the nuclear space in a complex primordial form determined by the whole genic apparatus. They would be alike for all cells of a given individual of a given species. On their course from the producing source into the cytoplasm, they would be subject to conversions and modifications. Especially, upon impact with certain specifically shaped template systems, they would assume conforming shapes and thus perpetuate particular molecular patterns. Since, as we tried to illustrate before, each cell strain in the course of its differentiation develops its own specific population of template molecules, the same primordial genic products will assume different shapes and properties depending on the particular molecular populations with which they make contact in the nuclear and cytoplasmic spaces. According to this concept, differentiated protoplasmic units would owe their origin and their specific shapes to two entirely different processes, occurring in different places. They would be propagated in the nuclear center, and be remodeled in the cytoplasm. These two phases might very well correspond to the two phases in protein synthesis (replication and folding) suggested by Haurowitz (1949). To use a crude simile, it would be somewhat like the making of furniture. The wood is grown by the forest but shaped by the carpenter. Neither does the carpenter grow wood nor does the forest shape benches. If this concept is correct, then what have appeared to be self-reproducing bodies in the cytoplasm would simply become model centers of adsorption, aggregation, alignment, and conversion of compounds which have originated in a distant location. We would have to call them "self-perpetuating," but not "self-reproducing," systems, as they would perpetuate their own pattern, template fashion, but not actually produce more of their own substance.

It is apparent from this discussion that on the strength of biological considerations, a sharp distinction is indicated between the continuous regeneration of existing protein molecules and the reproduction of new ones. Although tracer techniques have definitely established the fact that protein molecules are constantly exchanging fragments with corresponding fragments from the medium, thus preserving their statistical integrity (see Schoenheimer, 1942), there is absolutely no evidence as yet that fragments can ever be pieced together to form a whole protein molecule unless there is already a whole molecule present to serve as model. Thus, even on biochemical grounds, it would seem legitimate to distinguish sharply between the multiplication of protein systems (growth) and their mere maintenance and restitution, with or without concurrent changes of configuration (remodeling; differentiation).

Whether the dualistic concept of growth and differentiation proposed in this chapter can be substantiated by further research remains to be seen. Pending proof to the contrary, it deserves serious consideration as a possible alternative to the thesis of self-reproducing bodies in the cytoplasm which are supposed to be at the same time gene-dependent and autonomous. It is intriguing to compare our concept of the differentiation of cell strains, as here related, with the induction, transmission, and perpetuation of cytoplasmic varieties in protozoans with a common genome (Sonneborn, 1947). The parallelism seems to be more than superficial.

If growth is the result of nuclear synthesis followed by molecular conversion in interaction with cellular templates, growth rate will evidently depend on both the rate of synthesis and the effective concentration of templates. If the template conversion process is of the antigen-antibody type, antibodies against organ proteins might, by serving directly as templates, have an effect on growth rates. In 1939a, I reported preliminary results (with D. H. Campbell) indicating such a possibility, and in 1945 I suggested a generalized hypothesis of growth catalysis by complementary template systems comparable to antigen-antibody relations (Weiss, 1947). Tyler (1947) has advocated a similar "auto-antibody" concept of growth based on his extensive studies on complementariness in fertilization. However, neither the homology nor analogy of our hypothetical cytoplasmic templates with antibodies has actually been proved. Perhaps the demonstrated effect of specific antibodies on hereditary cytoplasmic transformations in *Paramecium* (Sonneborn, 1948) has a direct bearing on this problem.

GROWTH AND PATTERN

Tissues form as a result of association or non-dissociation of cells of the same kind, of the combination of cells of complementary types, and of the addition and interspersing of intercellular materials, which in turn are cell products. In the last analysis, therefore, histodifferentiation is the outcome of cytodifferentiation. As cells form increasing larger compound groups with an increasing complexity of interactions, they thereby set up novel conditions resulting from their group relations, to which the individual members of the collective now become subjected differentially, depending on their locations within the group. These emergent "field" conditions then become determining, or at least limiting, factors in the further course of growth and differentiation. One of the most striking examples in this class is the gradual confinement of proliferative activity in a tissue or organ to a circumscribed area (germinal cord or germinal layer: e.g., inner surface of the neural tube; rim of the optic cup; equatorial region of the lens; basal layer of the epidermis). In most of these cases, the proliferating area is characterized by some geometric peculiarity: the edge of a fold, the tip of a bud, the border between two tissues or between a tissue and fluid bathing it. These geometric positions obviously represent unique physico-chemical conditions of exposure which are not shared by other parts of the tissue. Cells removing themselves or being passively separated from those unique conditions, therefore, are automatically eliminated from further proliferative activity and usually continue in their differentiative course toward terminal stages (see Weiss, 1939). Plain as this correlation between geometric configuration and developmental fate is, we are still altogether ignorant of the mechanism by which it operates. We do not know what stops growth and mitosis in one part of a tissue, what maintains growth without mitosis in another (as for example in the steadily growing neuron), and what permits the germinal areas to go ahead with both growth and mitotic activity. For instance, does the cerebro-spinal fluid of the embryo contain a principle which supports mitotic activity in the adjoining neural epithelium, or does the mantle contain factors which suppress it? We do not know.

Detwiler (1947) and Harrison (1947) noted that in the process of regeneration of an extirpated lateral half of cord or brain from the remaining half, the regenerate showed numerous extraependymal mitoses. This observation might furnish a clue to further analysis, since the appearance of mitotic cells in the mantle could perhaps be related to the penetration of cerebrospinal fluid into the cell mass as a result of the operative disruption of the inner limiting membrane. In general, our knowledge of the causes underlying the appearance, subsidence, and focal localization of mitotic fields is extremely poor.

We are not much better off with regard to growth patterns in general. In a few selected cases we understand the basis of differential growth, at least in principle (see Weiss, 1949a), but for the most part even the mere biomechanics of the formation of tubes, folds, evaginations, ramifications, and so forth, are not much better understood than in the days of His and Hertwig, when they were first clearly formulated as problems. One thing we have come to realize is the great complexity of morphogenesis. What passes for differential growth is by no means merely a matter of differential proliferation, but is a mixture of cell movements, shifts of cell layers, aggregations, combinations, and separations, in addition to true proliferation; there is stretching and shrinkage, thinning and thickening, tearing and shedding, deposition and resorption. These are prime factors of morphogenesis. Growth thus does not really lay down morphogenetic patterns, but rather follows and elaborates them. In other words, it has become ever clearer that growth, as such, is a purely scalar process, producing simply more protoplasmic mass, increments without intrinsic direction. Direction is given to the growing mass not by properties inherent in the chemical mechanism of reproduction itself, but is imposed by physical properties of the space into which the material issues forth. Physical factors of given polarity, such as tensions, pressures, electric gradients, diffusion currents, fibrous pathways, and the like, appear among the factors that guide the deposition and extension of the growing material along preferential lines and channels. Growth has no sense of direction, and all directive growth owes its orientation to factors outside the loci of protoplasmic production. Some cells create their own physical frame to guide the growth of their protoplasm, as for instance, the heliozoa, whose arms are protruded by a crystalline axial skeleton, or the plant cells, whose cellulose wall determines by its longitudinal stretching the direction of cell division, and hence the polar growth of the cell column. In animal germs, the presence of a coherent fibrous surface coat presumably acts in a similar capacity. Since it weaves the cells into a common fabric, any systematic distortion of its meshes, as for instance, by the local contraction at the blastopore in the act of gastrulation (Lewis, 1947; Holtfreter, 1948a), introduces certain directive vectors into the movements, extensions, cell divisions, and internal rearrangements of the adherent cell sheets, and thereby sets a pattern for subsequent growth (see also Devillers, 1948; Trinkaus, 1949). The mobile cells of later developmental stages find similar physical guides in the protein network pervading the interstices of the body, and a major part of the phenomena of oriented growth can be explained by this principle of contact guidance (Weiss, 1941; 1948). At the same time, chemical factors contribute to growth patterns in a variety of ways, by modifying the structure of physical pathway systems (Weiss, 1934; 1949a), by establishing selective affinities between certain cells and certain pathways (Weiss, 1941; 1947), by promoting or inhibiting cell division (Lehmann, 1945), and generally, by taking part in all the component activities of morphogenesis listed above.

Consideration of this complexity renders senseless any attempt to classify effects on growth simply as "growth stimulation" or "growth inhibition." For example, the following are merely a few of the possible causes of "growth inhibition": lack of essential building blocks for protoplasmic synthesis, interference with the intake of essential compounds, lack of proper physical conditions for their assimilation, inadequate metabolic energy resources, space restrictions, active obstruction by neighboring units, blocking of the mitotic apparatus, etc., where each one of these contingencies may itself arise from a variety of causes. Anything then that partially or totally offsets any of these inhibitory actions would thereby automatically rate as a "growth stimulant."

The complexity of the process of growth should also discourage the continuation of those purely formal attempts to deal with it as if it were a simple entity (e.g., a "bi-molecular reaction"). It likewise minimizes the analytical value of growth curves for complex organisms. At the same time, growth curves have revealed over-all regularities which analytical preoccupation with the cellular mechanism of growth would hardly have disclosed. This goes for such phenomena as allometric growth, compensatory hypertrophy, effects of age on growth, and the like. Such observations bring us face to face with certain regulatory actions within the organismic system as a whole which have thus far proved most refractory to analytical investigation. References to homoeostatic maintenance of chemical balances, hormonal equilibria, competition for nutrient substrates (Spiegelmann, 1945) (which is merely a modern expression for Roux' classical "struggle among parts" or Robb's "partition coefficients"), metabolic gradients (Child, 1941), electric fields (Burr and Northrop, 1935), etc., are pertinent in illuminating each a particular facet of the problem. However, the fact that they all, in spite of their great diversity, seem to obey a common regulatory principle has never been explained in any but purely descriptive or evasive terms.

MORPHOGENETIC FIELDS

This brings up what is perhaps the most difficult and the most neglected of all basic problems in morphogenesis, that of super-cellular integration. Although behaving as individual units in their reactions, cells, when in a group, act as collectives. Such collectives exhibit properties and powers of "gestalt" character which are not recognizable in the isolated elements. One of the primary differences in a group is that of position. Secondarily, differences of position and exposure lead to differentials of activity and reaction. A simple and trivial example is the differential between center and margin. Any activity or property that varies systematically between center and margin of a given mass of active material will affect different members of the group differentially, depending on their coordinates in the system as a whole. The importance of the principle of patterned "field" activities in the determination of embryonic events has been generally recognized, and they have been given currency under such names as morphogenetic fields (Weiss, 1935; 1939a) or gradient systems (Huxley and de Beer, 1934). Yet their nature and mode of operation are still among the greatest puzzles of modern biology (see Sinnott, 1940).

If we were simply dealing either with differences in concentrations of substances arising from differential accessibility to food pools or accumulation of metabolites, or with electric gradients or with tension fields, or with any other single, uniform class of phenomena subject to a merely quantitative gradation along a linear scale of values, field activities could be understood, at least in principle, on the basis of existing concepts. A more penetrating appraisal shows, however, that no field concept operating with only a single variable can adequately represent the facts. After all, one has to explain that a determinative field vector causes not just a quantitative change in the activity of a responding cell, but selectively activates in the latter a specific performance from among a whole series of equally possible ones, perhaps by specific molecular segregations, as indicated earlier. This, it would seem, makes it imperative to concede to the field vectors the property of affecting molecular configuration and constellation, rather than only concentrations and reaction rates, with which a merely "quantitative" field theory would be concerned. It may become necessary to assume that at any given point of a particular field, conditions of such specific constellation arise that certain molecular groupings will be selectively favored or energized by a sort of resonance relation between field and molecular pattern. This is evidently a domain into which as yet no empirical road has been found. An identification of morphogenetic fields with electrostatic fields (Burr and Northrop, 1935) is undoubtedly simpler, but it cannot even remotely account for the subtlety of the relations which we are to explain. Granting the existence of electric fields, of metabolic gradients, and of other graded properties, and acknowledging differences of threshold among different cells for different combinations of these agents, this still leaves the structural order and systematic, qualitative variation of the field vectors in the different directions of space in a conceptual vacuum.

However, there is no cause for discouragement. There is merely cause for caution against premature generalization. Because of the forbidding difficulty of the field problem, the experimental procurement of more pertinent facts has lagged badly. It seems that more such information is needed before we can go on speculating. In this penetration into the unknown, we had better not tie ourselves too closely to the current predilection for diffusible chemical agents, but rather explore the possibility that field effects might be propagated by transmission rather than convection. That is to say, control over large cellular collectives may spread not by substances being bodily transported from cell to cell, but by states of molecular activities being relayed from one molecular system to the next (see also Wigglesworth, 1948).

The primary integrative actions of embryonic fields are in later development superseded by the various chemical coordination systems of the body, which are somewhat better understood. But even though we know the chemical composition and the general mode of action of many hormones, we are still far from understanding the selectivity of their terminal effects and the over-all harmony of their interactions.

CONCLUSIONS

I have sampled here some of the main current problems of morphogenesis. I have made it a point to illustrate the inadequacy of their present state, not in a spirit of defeatism, but on the contrary to emphasize the rich prizes the future holds in yielding solutions to those problems. I have indicated a few promising ways leading into the future, drawing disproportionately on examples from my own experience, not because I believe these ways to be more meritorious or rewarding than others, but simply to demonstrate that there are practicable ways, and to be concrete and convincing in this demonstration. The future of the field of morphogenesis will, of course, be what the workers in morphogenesis make it. The reawakened interest in its problems, the conjoint attack by formerly separated disciplines, the introduction of novel analytical tools, the growing conceptual precision, all these signs augur well that its future will be bright.

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NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will occasionally appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to H. B. Glass, Associate Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

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GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

THE WORLD OF LIFE. *A General Biology.*
By Wolfgang F. Pauli; edited by Bentley Glass. Houghton Mifflin Company, Boston, New York, Chicago, Dallas, Atlanta, and San Francisco. $5.00. x + 653 pp.; ill. 1949.

A casual glance at Pauli's text will show the reader at once that here is a unique general biology, even if only the selection of illustrations is considered. These are very numerous, attractively printed, and reflect a great ability on the part of the author, illustrator, and printer in working with original and clear illustrative media. The reviewer, in fact, has seen very few textbooks of any description that equal Pauli's in this respect.

A more than casual investigation of the subject matter of the book reveals that its approach to the study of biology is as unique as its illustrations, for the author has used the principle of evolution as his basic organizational theme. In developing this, he opens with a discussion of the nature of the universe itself and the behavior and structure of inanimate matter. This is followed by considerations of the general properties of cells that in turn lead to a presentation of evolutionary evidence and principles, including a brief survey of the paleontological record.

Sections on the rise of plants and animals follow, with the vertebrates receiving additional attention in a subsequent section. Finally the text closes with two chapters on genetics and eugenics, respectively. Two appendixes are included, one on the classification of plants and animals, the other on biological terms.

Generally, in these various sections, Pauli has written with a view toward topical completeness that of necessity prevents detailed discussion of any one topic. His style is lucid, and he avoids both the superfluity of biological terms too often found in biology textbooks and the omission of essential vocabulary.

The reviewer considers the inclusion of chapter material on the inanimate universe a most excellent idea that Pauli has carried out with great skill. Similarly, the organization of the book around the central theme of evolution has much to commend it, although it is apparent that opinions will differ as to what the most logical order for the development of this theme should be. It is to be noted in this regard, however, that this textbook should be useful regardless of the order in which its various chapters are considered.

In fact, rather than the order of presentation the teacher should consider the point that so much material is covered in the book that selection might have to be made in courses with restrictive schedules. This does not mean that the textbook will not prove to be successful in courses that are unable to consider all its contents. Rather, it should provide a strong background against which to teach biology, even though it may require some guidance of the student to prevent his becoming lost in the wealth of information presented.

The book would be strengthened by a presentation and discussion of the simpler mathematical formulations that are the basis of modern views on the study of population genetics and evolution. In addition, the reviewer would like to note that the opinions expressed on eugenics are not entirely shared by students of human genetics and suggest that the teacher not familiar with this material ought to refer to other discussions as well as those of Pauli.

The only error in printing detected by the reviewer was a minor one in the labeling of the figure on page 546. In closing it may be said that the publisher has done a superb job of presenting a book that should receive careful attention from all biologists interested in keeping their courses "alive and moving."

JOHN CUSHING

* * *

TELEOLOGICAL MECHANISMS. *Annals of The New York Academy of Sciences. Volume 50, Article 4.*
By L. K. Frank, G. E. Hutchinson, W. K. Livingston, W. S. McCulloch, and N. Wiener. The New York Academy of Sciences, New York. $1.75 (paper). Pp. 187–278; ill. 1948.

Contents: Foreword (L. K. Frank); Time, Communication, and the Nervous System (Norbert Wiener); Circular Causal Systems in Ecology (G. Evelyn Hutchinson); The Vicious Circle in Causalgia (W. K. Livingston); A Recapitulation of the Theory, with a Forecast of Several Extensions (Warren S. McCulloch). These papers, with some of the discussion that followed the presentation of each one, are interesting but they do not reveal any close connection with one another in spite of their stated relation to teleology and its mechanics. Each to his own taste—most biologists will find the article by Hutchinson particularly valuable.

BENTLEY GLASS

* * *

NEW BIOLOGY. *Penguin Books. Number 7.*
Edited by M. L. Johnson and Michael Abercrombie. Penguin Books, West Drayton, Middlesex, England. 1s. 6d. (paper). 128 pp. + 8 plates; text ill. 1949.

Contents: The Behaviour of Livestock (Alastair N. Worden); Recent Work on Spiders (Theodore H. Savory); Flowering of Plants in Relation to Environment (O. V. S. Heath); Chromosomes (H. G. Callan); The Seaweeds and their Uses (Alan J. Brook); Defining Vitamins (Pauline Whitby); Famous Animals —2, The Tapeworm (M. L. Johnson).

* * *

THE NEW AUTHORITARIANISM. *Conway Memorial Lecture. Delivered at Conway Hall, on March 22, 1949.*
By Lancelot Hogben. Watts & Company, London. 2s. (paper). x + 44 pp. 1949.

In his Conway lecture a year ago Lancelot Hogben warmed to his subject by directing a number of savage thrusts at C. D. Darlington, Conway lecturer of the preceding year. The New Authoritarianism, which many a scientist today views with apprehension, is in Hogben's eyes an outcome, perhaps an inevitable outcome, of large-scale enterprise. The very growth of scientific knowledge makes it impossible any more for us to identify "the scientific outlook with refusal to take propositions about external or human nature *on trust*." In higher levels of education and investigation the diminution of

> "concern for rational grounds of confidence is evident on all sides. The constant pressure of foundations which finance research, diverts the eager curiosity of the young investigator by speeding up publication of results in any field of inquiry with an aura of novelty. The policy of our institutions of higher learning penalizes honest effort devoted to the exposition of science to students or public alike by allocating academic promotion solely on the basis of mileage covered by repetitive reprints. In universities or Government research stations, heads of departments ostensibly appointed by reason of capability to do original scientific work soon discover that they are paid to be supersalesmen of problems nobody can solve . . . the temper of science itself in this context becomes increasingly more authoritarian . . . the pity of it is the complacency we have in common with every pre-existing culture in its decline." "Increasingly elaborate techniques call for expenditure on a scale which necessitates the support of either the State or of private foundations; and the new patronage imposes a new discipline on the process of discovery, reshaping the outlook of its personnel. To justify the newer and more costly techniques it is necessary to show results. Accordingly, a memoir in a scientific journal is less now, as once in my own lifetime, the announcement of a new discovery than a progress report on a cash advance. . . . He who pays the piper calls the tune."

Hogben concluded by quoting the Nobel Prize speech by H. J. Muller, which emphasized that continued growth in the freedom of the human spirit in inquiry and communication must be paralleled by "the bringing of the benefits of modern techniques to all, the raising of the standard of living of the broad masses everywhere, not exclusive of any groups or races . . . so as to make high culture and free criticism not the unstable possession of a limited sector of society, as among the ancient Greeks, but a part of the accepted inheritance of all humanity."

BENTLEY GLASS

* * *

ESSAYS IN PHILOSOPHY AND OTHER PIECES.
By A. D. Ritchie. Longmans, Green and Company, London, New York and Toronto. 12s. 6d. viii + 208 pp. 1948.

In this collection of essays published over many years and in many places, the Scotch philosopher has dealt with several subjects of particular interest to biologists. In The Biological Approach to Philosophy he has adopted a holist view. "The essence of life is transience and change.... From the observation of living things we get perhaps the clearest indication of what is meant by transience and by history." It not only follows that the quantitative mathematical treatment of phenomena characteristic of classical physical theory is most glaringly insufficient in biology, but it also makes it unavoidable to consider in biology "the notion of purpose." But Ritchie does not attempt to consider the quantitative as well as qualitative aspects of genetic control of development, and his argument seems very weak.

In Antiphon: a Pseudo-Socratic Dialogue on Natural Religion, Ritchie has given us a brilliant dissection of specious epistemological views and the nature of scientific knowledge. In the beginning worthy of Lucian at his best, in its latter part the dialogue seems to weaken when it passes on to consider the arguments for the existence of the Deity. Yet as a whole it is very thought-provoking. An essay on Samuel Alexander, British philosopher who was devoted to an evolutionary view of the theory of knowledge and, like Lloyd Morgan, to evolutionary emergence, sketches the main lines of thought of one who ought to be more widely known among students of the influence of Darwinian concepts.

Charming writing is to be found in two slight essays at the end of the book, about the isle of Dochet and the ghost port of Letang, both near the boundary between Maine and New Brunswick. Other essays deal with: Freedon; Can Commonsense be Trusted?; The Ethics of Pacifism; Miracles; Magic in Modern Politics; Errors of Logical Positivism; The Atomic Theory as Metaphysics and as Science; The Logic of Question and Answer; A Defense of Aristotle's Logic; Theories of Immortality; and Sir Isaac Newton: the Man and his Influence.

BENTLEY GLASS

◆

SCHOOL HEALTH EDUCATION. *A Textbook for Teachers, Nurses, and Other Professional Personnel. Harper's Series in School and Public Health Education, Physical Education, and Recreation.*

By Delbert Oberteuffer. Harper & Brothers, New York. $3.25. x + 405 pp. 1949.

This excellent text is the first of a new Harper's Series in School and Public Health Education, Physical Education, and Recreation, to be edited by the author. Written primarily for college and university students preparing to teach health education, it presents a comprehensive picture of a school health program, and describes the pedagogic techniques and principles being employed most successfully in the field of health education in our schools today.

The textual materials are presented under three broad headings: namely, (1) The Foundations of School Health Education; (2) The Curriculum and Teaching; and (3) Administration and Activities. Under The Foundations of School Health Education, the needs which have given rise to programs of school health education are discussed in relation to the school's responsibility in meeting those needs. The section on The Curriculum and Teaching covers the organization and techniques being widely used in courses of health education throughout the country at the present time. A sufficient variety of methods and materials are suggested here to meet the needs of a wide range of classroom situations and teaching techniques. The chapters in the section on Administration and Activities deal with the functioning of the school health program as it relates to the individual, family, and community. The discussions here are concerned with the problems of the handicapped, nutrition, safety, dental health, the control of communicable diseases, and the general techniques for measuring the effectiveness of the school health program. The volume will undoubtedly find a popular place in the field of methodology in health education. An index is provided.

B. AUBREY SCHNEIDER

◆

TRENDS IN MEDICAL EDUCATION. *The New York Academy of Medicine Institute on Medical Education, 1947.*

Edited by Mahlon Ashford. The Commonwealth Fund, New York; Geoffrey Cumberlege, Oxford University Press, London. $3.00. xiv + 320 pp. 1949.

This book covers the proceedings of a series of conferences held in April 1947 under the auspices of the Committee on Medical Education of the New York Academy of Medicine, and deals with current problems and trends in medical education. The panels and round table discussions are fully reported and include the following subjects: Premedical Education and the Selection of Medical Students, Undergraduate Medical Education, The Medical Education of Interns and Residents, Graduate and Postgraduate Training for Specialization, The Responsibility of Medical Schools and Hospitals in the Education of the General Practitioner, and The Relation of Group Practice and Community Medical Services to Medical Education.

DAVID B. TYLER

BIOLOGY: HISTORY AND BIOGRAPHY

BOTANIK DER GEGENWART UND VORZEIT *in Culturhistorischer Entwickelung. Ein Beitrag zur Geschichte der Abendländischen Völker. Pallas, Volume I.*

By Karl F. W. Jessen. [F. U. Brockhaus, Leipzig]; The Chronica Botanica Company, Waltham; Stechert-Hafner, New York City. $6.00 (paper). xxii + 495 pp. [1864]; 1948.

Eleven years before Sachs published his history of botany, which has long maintained its preeminence in its field, Jessen published this history of botany in relation to the history of culture. Sachs' history has been particularly valuable for its thorough treatment of 19th centrury plant physiology. Jessen's is unique for its cultural approach, which leads the editor, Frans Verdoorn, to acclaim it in the words: "little known as it may be at present, [it] is the best concise, all-around history of botany ever attempted." It has been reproduced by photo-offset, even to the original title-page. This will involve one inconvenience for most non-German readers, namely, the German Gothic script and the 19th century spellings, which scientists are not so accustomed to as are those in literary or philosophic fields. It is a very slight drawback—or perhaps none at all, depending on one's point of view—compared to the advantage of being able one's self to possess this valuable history. This is a most auspicious beginning of the Pallas series, in which Frans Verdoorn plans to bring us other out-of-print and classic scientific works.

BENTLEY GLASS

* * *

GOETHE ON NATURE AND ON SCIENCE. *Second Edition. The Philip Maurice Deneke Lecture Delivered at Lady Margaret Hall, Oxford, on the 4th March 1942. By Sir Charles Sherrington. Cambridge University Press, Cambridge, London, and New York.* 2s. 6d. 54 pp. 1949.

This delightful hour with Goethe and Sherrington is the Philip Maurice Deneke Lecture delivered at Oxford on March 4, 1942, and first published in that eventful year. For the present edition the author has "worked over the whole lecture again." It is a careful and well documented study, and full of the flavor of the irresistible but often impossible Goethe.

Although Goethe was an ardent student of Nature and the Sciences, and gave to the study of the shapes assumed by life the name by which it is now universally known, *morphology*, nevertheless Sherrington concludes:

> "Were it not for Goethe's poetry, surely it is true to say we should no longer trouble about his science. Such as it was, it is as science not important.... His enthusiasm as an observer of nature was great. But a new fact he met with was apt to send him on a flight of imagination into the unknown. Creative genius in literature, in science his genius longed to create. It could not always abide the waiting for further experiments and more knowledge.... Goethe, though devoted to science, had not at root the scientific temperament. He had not, for instance, along with the urge to discovery the sublime detachment of the scientific thinkers."

In Goethe's time there had arisen a desire to catalogue and arrange in order all the kinds of plants that are, the assumption of the time being that the kinds around us are still as at the creation of the world. Goethe, however, had noticed such differences between specimens of the same species that he thought specific form might be in a state of flux. The continual change which he suspected was going on in plant form Goethe attributed to the influence of environmental conditions, such as type of soil, light, warmth, moisture, etc. Thus both Goethe and Lamarck dissented from the Linnean "frozen" view of species, although the latter was the orthodox view. One recalls that the isotopic evidence of the continuous interchange of protein amino nitrogen with the environment did not then intrigue observers of biological continuity, and altogether there has been many a mutation since Goethe sang of change and flux.

However, many of Goethe's ideas were less fortunate. For example,

> "Goethe never reconciled himself to the Newtonian notion of light, although it became the standby on the subject for the scientific world.... In following Goethe's science, we are helped by his having laid down principles which in his view should govern scientific observations. One of them is that the conditions for observations should be kept as simple as possible, and for that reason should eschew apparatus. Prominent in his objections to the prism experiment was that the prism introduced heaven-knows-what complications. Essential for scientific observation was *Anschaulichkeit* 'obviousness' or 'naked clarity.' This clarity could dispense with mathematics,... which had brought calamity to optics. He did not see that the use of apparatus is to simplify conditions. Nor, again, that mathematics can be a main means toward obtaining *Anschaulichkeit.*
>
> "As regards science, Goethe lay becalmed, so to say, in a small quasi-scientific backwater of no great account. But Boyle had been starting modern chemistry, and Lavoisier, Cavendish and Dalton had established it. Lagrange and Laplace had annexed the nearer heavens for Newton. [This while Goethe was dealing with material forces by notions ad hoc out of his own fancy.] Further, Goethe's pronouncements were shot through with anthropomorphism, which, unless used purely as metaphor, *is* the occult. In Goethe it *is* the occult. *Polarität, morphogenesis*, and so on, have 'yearnings,' 'likes,' 'will,' etc. We are back in the mediaevum and early renaissance."

Goethe's isolation from the main stream of the science of his time finds an interesting parallel in a sort of political becalm, a lack of insight into the significance of the French Revolution and a failure to appreciate its positive aspects. Although he does not stress the parallel, Sherrington finds that "the *sans culottes* of the revolution were to him a hopeless problem as well as a repellant mob. Thompson's poem on 'Liberty' failed because 'there was no poetry in the theme "Liberty."'' The cry *égalité* was hateful to him, even in its context of that great assertion of the rights of man, that doing away with feudal privilege.

Alas, that our men of letters do not always exhibit an insight into their times that is of a quality with their eloquence. Goethe is our friend, "but the truth is even more our friend."

EVELYN HOWARD

⁂

LIBERTY HYDE BAILEY. *A Story of American Plant Sciences.*

By Andrew Denny Rodgers III. Princeton University Press, Princeton. $7.50 viii + 7 plates. 1949.

Liberty Hyde Bailey, the most recent of Andrew Denny Rodgers' series dealing with eminent botanists, is far more than a mere biography. Rather, it is a comprehensive survey of the development of scientific agriculture in the United States and Canada, and an account of the advances made in botany and zoology during the present Century. Liberty Hyde Bailey is the central figure in this great drama, and any account of his life and work must of necessity be primarily concerned with the great achievements in plant science for which he was wholly or in part responsible.

The story of the founding and development of the United States Department of Agriculture, the establishment of agricultural colleges and of departments of agricultural science in many older institutions, and the setting up of the nation-wide chain of agricultural experiment stations form the background of this book. Interwoven with this framework is a fascinating account of the work of the stations, the advances in experimental research, and the initiation of entirely new branches of science, such as horticulture, plant breeding, and phytopathology. Through it all runs the thread of Bailey's own career, from its humble beginnings on his father's Michigan farm to his present honored position as the nestor of American botany. Few men have contributed so much to plant science and to the welfare of the rural population. Horticulture, floriculture, scientific agriculture, forestry, nature study, rural life education, and taxonomy have all benefited directly. Whether as Professor or as Dean, as the world's leading agricultural author and editor or as Chairman of the Country Life Commission for the improvement of country living, his influence has been great.

The story of the last fifty years and more of plant science in the United States, however, is more than the story of one man's accomplishments, however great they may be. In the author's presentation scores of other botanists play a part and their work is evaluated and brought into proper focus.

The book is so full of factual information derived from letters, documents, collections, and all other available records that no review can begin to do it justice. It must be read to be appreciated—and read at one's leisure—in order to assimilate the wealth of material within its pages. Suffice it to say, *Liberty Hyde Bailey* is a worthy successor to *Noble Fellow*, *John Merle Coulter*, and *John Torrey*, and carries the saga of North American botany another step nearer completion.

ALBERT F. HILL

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LE FRÈRE MARIE-VICTORIN ET SON TEMPS. *"Voyez les Lis des Champs."*

By Robert Rumilly. Les Frères des Écoles Chrétiennes, Montréal. $2.00. (paper). ii + 459 pp. + 41 plates. 1949.

Frère Marie-Victorin was born at Kingsley Falls on April 3, 1885. He was baptized Joseph Cyrille Conrad Kirouac. The Kirouac family traced itself back into the Middle Ages, and its first representative came to New France in 1730. The young Conrad was educated at L'Académie (Commerciale) de Québec, and in 1901 became a novitiate at Mont de la Salle in Montréal. Throughout the remainder of his life, he was a lay brother associated with this organization. Early in life he became interested in botanical research and exploration and continued his work in this field until his death. He was widely known and appreciated as a taxonomist and plant geographer through the world, and was a leading figure in the development of modern botanical research and instruction in French Canada. The present volume will be of great interest and value to his many friends, associates, and students. It appears to be a rather definitive biography, dealing not only with Brother Marie-Victorin's many accomplishments, but with the influences that shaped his life. The book is profusely illustrated with photographs, is arranged with explanatory chapter headings, and contains an extensive index.

H. M. RAUP

⁂

AMERICAN HEARTWOOD.

By Donald Culross Peattie; decorations by David Hendrickson. Houghton Mifflin Company, Boston. $3.50. x + 307 pp.; ill. 1949.

In his usual colorful language Peattie has reviewed the common heritage of all Americans, our trees. He parallels the history of our nation with the development of the sturdy heartwood of a tree, "widening ring by ring and year by year—seeking a tall, straight way toward the highest light." Here is a most pleasant way to appreciate the nation's growth, "for man and trees are partners in the American story." Following the exploration and trial settlement of the Icelander Erik the Red, we are taken through The Groves of Columbus, learning such unfamiliar facts as that the generous natives gave Columbus "some dried brown leaves," the offer of which he failed to appreciate, so discarding tobacco without knowing that this present was worth "more in gold than all the spices" he sought. His quest, in fact, was for rhubarb! Peattie leans heavily on his own familiarity with the wooded land and deserts through which the Spanish searched for gold, but concludes his account of their ruthless expeditions with the comment that Sante Fe "is Spanish country still, with the gold leaf of the Spanish tradition laid on the crude carving of the Indian way of life."

Amidst the long leaf pines the story of John White is unfolded—that of the first man to have a scientific and artistic appreciation of American greenery. John Smith comes to life in his record that "The country is most overgrown with pynes—the wood that is most common is Oke and walnut. . . ." A succession of stalwarts—Roger Williams, William Penn, John Marshall, Andrew Jackson and others—come down to us, each surrounded by a heritage involving trees. The subject extends into forceful chapters on Old Ironsides, herds of bison, and Virginia City. Threaded throughout is discussion of Peattie's forthcoming treatment of the northeastern sylva, showing that here is one book about another. In writing *American Heartwood*, the author explains that "this book of mine is for me a holiday. I am journeying in it where my fancy takes me. And when you are making ready such a journey, you put in what you please, and leave out whatever you don't care to be bothered with. Such irresponsibility would never have done, in the book I have just finished about trees." So it is that the reader comes to know Peattie's home in Santa Barbara and the great oaks which protect it and inspire him.

For anyone who has roamed these United States this book combines new facts, smooth writing, and reminders of personal experiences in many places. It is rich in history and nature, for no matter when or where one travels, "the wonderfully steadying thing about the identities in Nature is that they do not change through all the desperate flux of men's affairs." The book deserves an index.

LORUS J. AND MARGERY MILNE

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NATURALIST'S SOUTH PACIFIC EXPEDITION: FIJI. *By Otto Degener. Paradise of the Pacific, Honolulu.* $5.00. viii + 303 pp.; ill. 1949.

Otto Degener was guest botanist to the second "Cheng Ho" expedition in 1940-41. The expedition was under the sponsorship of Mrs. Anne Archbold, and undertook primarily scientific exploration among the Fiji and neighboring islands. It set out from the Philippines in the latter part of 1940 and went directly to the Fiji Islands. There Degener left the ship and spent the remainder of his membership in the expedition collecting plants. During some eight months' work, he accumulated about 2100 collection numbers of Fijian plants, which were sent for study and determination to Albert C. Smith of the Arnold Arboretum and to other specialists. E. D. Merrill, then Director of the Arnold Arboretum, and W. J. Robbins, Director of the New York Botanical Garden, were in general charge of the handling and distribution of the collections.

Degener's book, though it contains as an appendix a numerical list of the collections, is primarily a nontechnical account of his travels and experiences in the Fiji Islands. It is eminently readable, lively, and interesting. It is profusely illustrated with modern photographs and reproductions of old prints. Degener is a man of wide experience in travel and botanical exploration in the Pacific. He has been extraordinarily successful at training native assistants, who have served him not only in a technical capacity for his botanical work, but as informants on native lore. The author's botanical experiences are interspersed throughout the book with colorful descriptions of the native life and its setting, and with his quite uninhibited comments upon what he thinks of native customs, British colonial policy, the efforts of missionaries, and the future of the country. There are intriguing chapters, for instance, on native hair-dos, the institution of cannibalism, and races of man in the Pacific.

H. M. RAUP

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SVALÖF 1886–1946. *History and Present Problems. Edited by A. Akerman, O. Tedin, and K. Fröier; English technical editor, R. O. Whyte. Carl Bloms Boktryckeri, Lund.* Kr. 20.00; $6.00. vi + 389 pp.; ill. 1948.

This interesting collection of papers presents a survey of the 60 years of scientific plant breeding carried on by the Swedish Seed Association at the Svalöf Institute. The book was prepared in the hope that it might reaffirm the desire of Svalöf to participate in programs involving international cooperation in genetical research. Each of the 22 separate articles was prepared by a specialist. Some of them are general in nature and deal with the history of the Institute, its organization, or such topics as climate and soils, biochemistry, and the publications of the Seed Association. Others outline the principles underlying the experimental work or are concerned with the experience gained in recent years. Of particular interest are the chapters devoted to the more modern fields of investigation—cytogenetics, polyploidy, and x-ray breeding. A wide range of plants is discussed, including wheat, oats, barley, rye, potatoes, root crops, oil plants, flax, hemp, herbage plants, alfalfa, and others of minor importance. The excellent typography and illustrations add much to the value of the book.

ALBERT F. HILL

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HUANG TI NEI CHING SU WEN. *The Yellow Emperor's Classic of Internal Medicine. Chapters 1–34. Translated from the Chinese with an Introductory Study.*

By Ilza Veith. The Williams & Wilkins Company, Baltimore. $5.00. xx + 253 pp.; ill. 1949.

This is a translation of the first 34 chapters of *The Yellow Emperor's Canon of Internal Medicine,* the most famous Chinese classic on the subject. The legendary Yellow Emperor, Huang Ti, lived supposedly between 2697 and 2597 B.C. The book that bears his name was probably composed in the first millennium B.C. The text that served as a basis for the translation stems from the eighth century A.D.

The translated chapters are in the form of dialogues between the Emperor and his minister Chi Pai on the problems of disease and the healthy and good life, in the framework of Chinese basic natural philosophy (Tao, Yin and Yang). In typical Chinese fashion organs are related to these basic principles, to elements, and to seasons in an elaborate system of mystical numbers. The fundamental approach in diagnostics (the pulse) and the nature of therapeutics are discussed. Moxa and acupuncture are treated in more detail. Whether that most important element of Chinese medicine, its pharmacopoeia, is absent only from the translated chapters or from the whole book, is not mentioned by the translator.

This first translation of important parts of a Chinese medical classic into English is a medicohistorical event, the magnitude of which needs no further elaboration. All those who have contributed to it, especially Ilza Veith, the late J. W. Lindau, H. E. Sigerist, and the publishers, deserve our heartfelt gratitude. Ilza Veith, who has so successfully struggled with one of the most difficult tasks imaginable in the art of translating, has enhanced the value of her book by an excellent historical introduction and well chosen illustrations. The printers have also done well in a difficult task requiring the combination of ideographs with our own letters.

ERWIN H. ACKERKNECHT

Volumen Medicinae Paramirum of Theophrastus von Hohenheim Called Paracelsus.

Supplements of the Bulletin of the History of Medicine, Number 11.

Translated from the original German with a Preface by Kurt F. Leidecker. The Johns Hopkins Press, Baltimore. $1.75 (paper). viii + 69 pp. 1949.

In this little treatise the famous sixteenth century physician and "reformer of medicine" gave his opinion on the cause of disease. Disease, he thought, is not a product of the bad mixture of the four humors, as assumed by his predecessors, but stems from five sources: the ens astrale, the ens veneni, the ens naturale, the ens spirituale, and the ens Dei. The development of the human body is not conditioned by the constellation of stars at birth, as the astrologists claim. This is caused by an ens seminis (genes?). But the stars produce disease through poisonous gases. This is the ens astrale. Every food can poison, when the "alchemist" of the body fails. This is the ens veneni, in a way an anticipation of metabolic disease. The body is a microcosm. Its sun is the heart, its moon the brain, its Jupiter the liver, its Saturn the spleen, its Venus the kidneys. Out of the "constellation" of these "planets" disease may arise. This is the ens naturale. Attack of the will of another person on one's own will, with or without sorcery, may create disease. This is the ens spirituale. That this chapter sounds often like our "psychosomatic" reasoning is as much the product of the immaturity of our own psychology as it is a matter of Paracelsus' foresight. The last cause of disease is the will of God (ens Dei). It is also only God's will that heals through the physician. God sends disease as an affliction, and it cannot, therefore, ultimately be understood.

The treatise is a fair specimen of Paracelsian thought: a strange mixture of some great sense and far more nonsense. Longwinded and mystical as usual, it is relatively poor in his customary outbreaks of invectives and megalomania. Paracelsus' great "reform" consisted in replacing an old speculative system with a new speculative system, based no longer on exclusive "pagan" rationalism, but on a Christian mysticism that might be emotionally sympathetic, but is scientifically sterile. Yet Paracelsus has to be studied, whether one regards him as a great thinker and physician, as his translator does, or as neither, as it seems to the reviewer. Yet Paracelsus, and not Vesalius, Fernelius, or Fracastorius, was the representative physician of his time. From this point of view the Hopkins Institute of the History of Medicine is to be congratulated that it continues to make available the Paracelsus texts in good English translations.

ERWIN H. ACKERKNECHT

Life among the Doctors.

By Paul De Kruif, in collaboration with Rhea De Kruif. Harcourt, Brace and Company, New York. $4.75. x + 470 pp. 1949.

De Kruif's latest book follows very much the pattern of his earlier successes: a bouquet of biographies, this time of "doctors," pioneer medical scientists of our time. Three of them are remarkable public health men: C. C. Young, Herman N. Bundesen, and O. C. Wenger. There are portraits of Tom Spies of vitamin fame, Al Coburn, fighter against rheumatic fever, Leo Loewe, who tackled S. B. E., the neurologist Herman Kabat, Sidney Garfield of the Kaiser Health Plan, and the "great old man" of American medicine, (probably L. Hektoen), fighting cancer, who wants to remain anonymous. The same "corny" old plot is used: the hero, creating a miracle, is continously harassed by the villain, in this case the medical profession. The same old cheap, "breezy," style, full of slang expressions, prevails. DeKruif's popularity as a writer seems to be based mainly on the fact that the unfortunate average citizen of this ex-puritan country has still guilt feelings even when swearing or drinking, and cannot help but admire a man who does not suffer from his inhibitions and lets out a Goddam every so often.

But this book, which pretends to contain a message for the salvation of mankind through scientific medicine, is not primarily a problem of style and taste, but of *truth.* It must be stated that it contains mostly half-truths. All the men DeKruif has described are in a way admirable men, but none of them has played exactly the role DeKruif attributes to him. As a historian DeKruif is so careless with facts that he does not even get the first name of the discoverer of vaccination straight. As to the "villain," the medical profession, this reviewer, though himself an M. D., feels free enough from prejudice to admit regretfully that about 50 per cent of the author's accusations are truthful. When, on the other hand, the author repeatedly claims that "doctors" are opposed not to social but to medical progress because they fear to lose their business, the accusation is not only monstrous, it is untrue. Doctors are fortunately a lot better than their official representatives try to make them look. (DeKruif proves his fundamental lack of seriousness by making an indirect recantation of all his accusations in the preface to a second edition, just because in the meantime the American Medical Association dismissed its editor, a man whom DeKruif happens strongly to dislike. That the A. M. A. continues to pursue the same policies through some even more objectionable characters seems not to bother a subjectivist of DeKruif's sort.)

There are a few things that the author, when judging doctors, either does not know or does not understand: for instance, that all his miracle drugs are of little benefit to 70 per cent of an average doctor's clientele, or that treatments not only cure, but often also kill. Failure or toxicity of drugs are practically not in DeKruif's vocabulary.

The reviewer has had to think about this book a good deal, because it is in many ways highly stimulating through its criticism and its enthusiasm. Regretfully he has to admit that he has been unable to reach a clear-cut decision. As a scientist, wedded to the "whole truth," he would utterly condemn it. But in a field so heavily obscured by the smoke of straight untruth used as propaganda, even to read half-truths might prove of some positive value.

ERWIN H. ACKERKNECHT

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THE WORKS OF GEORGE BERKELEY, BISHOP OF CLOYNE. *Volume I. Philosophical Commentaries; Essay Towards a New Theory of Vision; Theory of Vision Vindicated,*

Edited by A. A. Luce. Thomas Nelson and Sons Ltd., London, Edinburgh, Paris, Melbourne, Toronto, and New York. 30s. net (provisional). viii + 279 pp. 1948.

This is the first of a series of eight or nine volumes planned on the works of George Berkeley. The present volume contains three of Berkeley's writings: *Philosophical Commentaries, An Essay Towards a New Theory of Vision* and *The Theory of Vision or Visual Language Shewing the Immediate Presence and Providence of a Deity Vindicated and Explained.*

The *Philosophical Commentaries* is actually a collection of some 900 notes, not intended for publication, and originally contained in two notebooks. They are jottings that Berkeley made of the thoughts and queries that he had when he was trying to work out his theory of vision and his metaphysical doctrine. The entries are at first glance bewildering and disconnected, but it is easy to see here the antecedents of arguments which found their way into his later writings. The *Essay* is a classic in the history of psychology and philosophy. In it, Berkeley carefully analysed the psychological cues for the perception of size and distance and laid the groundwork for many of our current ideas on the subject. *The Theory of Vision* was a shorter work, written in reply to an anonymous critic of Berkeley's *Essay.* The entire collection is carefully and minutely annotated by the editor.

A. CHAPANIS

ECOLOGY AND NATURAL HISTORY

BOTANY OF THE CANADIAN EASTERN ARCTIC. *Vegetation and Ecology, Part III. National Museum of Canada, Bulletin Number 104, Biological Series Number 32. By Nicholas Polunin. National Museum of Canada, Department of Mines and Resources, Mines and Geology Branch, Ottawa.* 75 cents (paper). viii + 304 pp. + 1 map; text ill. 1948.

Part III of Polunin's series on the botany of Eastern Arctic Canada was actually finished in the early years of the last war, and its publication was thus greatly delayed. Part I, consisting of a catalogue of the vascular flora, was published in 1940; and Part II, a catalogue of the non-vascular plants, came out in 1947. Part IV, projected for the future, is designed to cover certain features of the "sub-Arctic" regions.

The present volume is well written, and profusely illustrated with photographs. There are 107 of these plates. Two maps are given, one a sketch map at the beginning of the book showing the geographical divisions used in the text, and the other a larger, more detailed map of the Eastern Arctic, folded and placed in a pocket at the back.

The general plan of the book is on a geographic basis. Ten subdivisions of the area are recognized, as follows: 1) Ellesmere Island; 2) Devon, Cornwallis, and Somerset Islands; 3) the northern part of Baffin Island; 4) central Baffin Island, including Cumberland Peninsula, the land around Cumberland Sound, and Nettiling Lake; 5) southern Baffin Island, including the Foxe Peninsula; 6) the Melville Peninsula; 7) northernmost Labrador, consisting of the small tip of the peninsula east of Ungava Bay and north of the 60th parallel; 8) northernmost Quebec south to the 60th parallel; 9) the islands in Hudson and Ungava Bays, such as Southampton, Coats, Mansel, and Akpatok; 10) the west coast of Hudson Bay south to latitude 60 and including all of Wager Bay. Descriptions of vegetation and local ecology are given for each of these areas, with the pattern of treatment repeated in each area. A list of headings for the treatment of Ellesmere will be fairly typical. First come sections on geology, climate, and a general treatment of vegetation types. These are followed by more or less detailed descriptions of specific areas visited by Polunin himself. In the case of Ellesmere Island, the locality was at Craig Harbour, and the communities are described under the following headings: uplands; scree and other slopes; lowlands; marsh; snow effect; special localized habitats and communities; fresh water; strand; and marine.

The book contains, usually under the general description of the vegetation in the various geographic areas, a wealth of material gleaned from earlier travel and description. Those who have undertaken this kind of research will appreciate the immense amount of painstaking labor that went into the gleaning of these historical data. Most travelers do not describe vegetation in terms that are specific enough for a plant geographer. Nevertheless, when one is familiar with the general botanical landscape in which the travelers have lived, it often becomes possible to make quite accurate interpretations of their sketchy accounts of vegetation. Polunin has succeeded in doing this effectively for many areas.

This reviewer would like very much to have had the author make some attempts at generalization within the huge mass of material that he has presented. Even though such generalizations would have given rise to controversy over concepts, and would have been based upon many uncertain premises, yet they would have been stimulating. This is especially true when the nature of the development of Arctic vegetation is being studied intensively, as it is now. Polunin presents the following defense of his lack of attempt at generalization.

> "In tackling what is thus an almost virgin though huge field I have been struck by two apparent anomalies. The first was that the vegetation of the southern part of the area was even less known than that of the north, though this is not inconsistent with the northward trend of exploratory activity of the past few decades. The second has been that the more I learned about the vegetation of the area as a whole, the less I felt inclined to generalize about it; for if one impression stands out from among all my studies of the vegetation of the Canadian Eastern Arctic, it is that of extreme (and often to me inexplicable) variability from place to place. Certainly there will long remain a great deal more to discover; nor is our knowledge as yet nearly sufficient to allow of detailed comparison with other arctic or subarctic lands."

Anyone who has attempted to describe tundra vegetation will know what is meant by this. It points clearly to a conclusion reached by Griggs and others that the tundra vegetation will not yield to analysis by the methods usually used in the temperate regions, and that new methods and points of view must be constructed.

H. M. Raup

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Pilchuck. *The Life of a Mountain.*
By Harry W. Higman and Earl J. Larrison. Superior Publishing Company, Seattle. $3.50. xiv + 288 pp. 1949.

Pilchuck, the subject of this story, is an isolated mountain in the Cascades of Washington. The authors have selected it because its isolation makes it relatively easy to consider as an ecological unit (if such a unit ever exists). The story of the life on this mountain is told in popular style, in such a manner that even a simple incident becomes interesting. The authors have employed a very clever device to carry their story in centering it around the observations of three friends who spend all their available time exploring the mountain. One of these friends, an educated amateur naturalist, writes in the first person and thus brings the other two into the narrative. The second man is a professional ecologist, and the third an untutored naturalist, representing the modern counterpart of a frontiersman. The discussions that go on among these men enable the authors to present various views and arguments relating to the ecological problems of the mountain.

The result is a book that portrays, as well as any the reviewer has read, the great personal satisfaction and pleasure that can be derived from studying ecology, as well as the relative ease with which even an amateur can start such work. The scientific values of these studies are also clearly brought out in various discussions relating to soil conservation and wildlife management. Interested amateur readers might well use this book as a guide for starting similar projects of their own, selecting isolated ecological "units" such as islands, beaches, ponds, or stretches of streams for study.

John Cushing

HIGH JUNGLE.

By William Beebe. Duell, Sloan and Pearce, New York. $4.50. xii + 379 pp. + 32 plates; text ill. 1949.

"High Jungle" is the region around Portachuelo Pass across the Cordillera of Venezuela. Here, in the enormous half-finished concrete palace of an extinct dictator, Beebe and his associates established a biological laboratory. For three seasons (1945, 1946, 1948) they studied the passing procession of birds, moths, beetles, monkeys, snakes, frogs, ants, and innumerable other animal species, as it passed before the backdrop of giant trees and lianas, tree ferns, orchids, and other jungle plants. Off to the north, a few miles of precipitous drop to the blue Caribbean; off to the south, and far below the verandas of Rancho Grande, the brown, dusty savanna, the lights of Maracay, and the glistening waters of Lake Valencia; in the Pass, alternating sunshine and fog revealing and concealing the teeming life of the high jungle, and modifying its ways as much as its appearance.

In the thirty years since *Jungle Peace*, Beebe's first popular book, his observation has lost none of its keenness, his prose none of its color. Whether he is describing the giant 6-inch land planarians or the great gray frog which hatches its young from its own back, the lives of the jungle falcons or the inconceivable swarms of moths beating at night through the Pass and against the lighted windows of the laboratory, or the fantastic moth which builds a palisade for its caterpillars out of its own scales, Beebe's zest never flags. The book contains numerous excellent illustrations from the expedition's photographs. In short, *High Jungle* is a fine addition to a great series of books of natural history.

BENTLEY GLASS

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THE SEA SHORE. *The New Naturalist: A Survey of British Natural History.*

By C. M. Yonge. Collins, London. 21s. xvi + 311 pp. + 72 plates; text ill. 1949.

This book is the culmination of more than a hundred years of such books about the seashore life of Britain. The author is fully aware of this long and honorable tradition, as his historical chapter, bibliographic appendix, and the use of charming quotations from his predecessors as chapter headings alike indicate. Many of these books were well, if not quaintly, written and illustrated with meticulously accurate paintings and precise drawings. Others were miserable hack work now deservedly forgotten. Now, with the aid of a master photographer, Yonge has left almost nothing for his successors in England to add or improve upon, and has set up a model for anyone who undertakes to write about another shore.

Although the subject of this book is the intertidal zone of the English coast and its plants and animals, it is not a provincial book. The chapters on the nature of the shore (except for the discussion of tides, which applies to English shores specifically), borers into rock and wood, sandy shores, estuaries, and shore populations, to name some of the most outstanding, are drawn from the author's wide experience and are applicable anywhere. In addition to being highly readable, they deserve to be used as reading assignments for students in seashore biology classes, both on account of their subject matter and as an antidote for the dry diet of textbooks and wilted reprints. The whole book is a blend of personal experience and observations with the recent issues of the *Journal of the Marine Biological Association.*

The photographs, most of them by Douglas P. Wilson, are almost beyond compare, and will be the despair of all other photographers. To see the coast of England, as shown on these color plates, is certainly a very fine second best to an actual visit to the scenes. As for the portraits of the animals themselves, no better photography has ever been published. There are things the camera still cannot do, in so far as the precise requirements of the taxonomist are concerned, but the margin between the camera and the lithographer's stone is narrowing down. The printers have risen to the occasion, and the color work is on the whole excellent.

JOEL W. HEDGPETH

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AMERICAN SPIDERS. *The New Illustrated Naturalist.*

By Willis J. Gertsch. D. Van Nostrand Company, New York, Toronto and London. $6.95. xiv + 285 pp. + 70 plates. 1949.

It is with extreme pleasure that this reviewer reports on *American* Spiders, the second volume in the New Illustrated Naturalist series. This excellent book represents the result of almost a quarter of a century of laboratory and field work of one of our leading araneologists. While all specialists will naturally want a copy, it may prove to be of even more value to the general biologist, the entomologist, and particularly the naturalist, who will be delighted to discover the fascinating attributes of spiders.

The first few pages are devoted to a discussion of the place of spiders among other animals in nature, and to a brief description of their general morphology. The greater part of the book is given over to the habits and lives of these creatures, including their embryonic development, hatching, growth and molting, feeding habits, autotomy, and longevity. While most people may think of spiders' habits only in terms of webs spun to entrap prey, Gertsch has elaborated on the many other uses to which spiders put their silk, e.g., nursery webs, hibernating chambers, ballooning lines, egg sacs, and a host of others. Also included is an account of how human beings, too, have used the silk, as fishing nets in Papua, as cloth for garments, or as cross-hairs in optical instruments. Besides mentioning the role of spiders in classic myths, Gertsch also recounts many little-known legends which show the importance attached to spiders by numerous primitive tribes.

An entire chapter is devoted to the sexual behavior of spiders, their remarkable courtship habits and mating positions being described in great detail. It is regrettable that the morphology of the reproductive organs has not been described sufficiently, and that not a single illustration of these organs was included. The reader who is unfamiliar with spiders may not entirely comprehend the discussion without reference figures, while for the specialist figures would have been useful in lending support to the "lock and key" theory, to which the author adheres. Another omission from the book is any consideration of the parasites of spiders.

Although a few of the more common or conspicuously marked species may be identified from the author's descriptive notes or from the illustrations, the volume is not intended as an aid in determining species, so that for this purpose recourse must still be had to manuals. Information about the different families has been grouped under four headings, and for each heading a separate chapter is reserved. These include first the tarantula and trap-door spiders, then the hackled band weavers, third the aerial web spinners (including the majority of spiders known to the casual observer), and finally the vagabond hunters (such as wolf and crab spiders) which do not build snares. To most readers the well-authenticated accounts of the spitting spider, of the bolas-throwing spider, and of those that catch fish, will seem almost incredible.

Considerable space is devoted to the economic importance of spiders, especially to arachnidism. After a background survey of the legends surrounding the Italian "tarantula" (in reality a wolf spider), one is introduced to the several species of which the bites are known to be dangerous to man. A full account is given of the black widow, its control, symptoms of its bite, and the remedies that have been found useful in alleviating symptoms.

The final chapter deals with the relationships and affinities of the North American spider fauna, and includes a scheme of classification different from the usual one, in which the liphistiids are placed by themselves in a separate suborder. The author advances some convincing reasons for classing these primitive spiders with the purse-web weavers, the folding trap-door spiders, and others, as atypical tarantulas, in the same suborder with the typical tarantulas and their allies. Certain other groups generally considered families have been sunk to subfamily status, and a number of the subfamilies have been elevated to higher rank. The book closes with a glossary of technical terms, a short bibliography, and an index.

The volume is superbly illustrated with 32 plates in full color and 32 in gravure. Most of these are by outstanding masters of the photographic art and are in themselves important contributions to spider study. The publishers are to be congratulated upon combining so well the work of these men with that of W. J. Gertsch. Undoubtedly the numerous minor typographic errors will be corrected in time for the next printing, thus improving a book that will in all probability long remain *the* outstanding volume on these much maligned but extremely interesting animals.

B. J. Kaston

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Webs in the Wind. *The Habits of Web-Weaving Spiders.*

By Winifred Duncan. The Ronald Press Company, New York. $4.50. xvi + 387 pp.; ill. 1949.

The best thing about this book is its title, but that lyrical phrase is only a deceptive lure to read a volume which has a sickeningly coy style throughout. In the preface the author states: "It has long been my intention to select some little creature concerning which I know nothing, make a careful study of its life, and write a book about it which would take the reader along with me, step by step, on a voyage of discovery." Undoubtedly the author was sincere in this laudable aim. However, the following comments should be sufficient to show that by using the methods she chose the author's voyage of discovery could end only in catastrophe. To enumerate all the errors of fact, misspellings, misinterpretations, and imagined occurrences would more than fill the space allotted here.

After stating her reasons for choosing spiders for study, she continues: "... it is the more amazing that so little work has been done in this field...." Her bibliography contains but 14 titles, and it is evident throughout the book that the author is completely unaware of the vast amount of work that has been done on this group within the past half century, not only in America but elsewhere in the world. Yet she feels qualified to condemn previous workers with words such as these: "with his usual inaccuracy" Comstock states; or Hingston is "rather too apt to make general conclusions from insufficient data." The latter statement is especially startling when coming from a worker who indicates that she ceased her observations after 10 minutes, because she was tired, and yet will make dogmatic statements based on virtually no evidence.

Winifred Duncan resolved that her book would contain no information rehashed from other books, nor any borrowed drawings. Almost immediately, however, curiosity overcame her and she "peeped into just one old spider book I happened to have to verify my own observations." Later she bought more books into which she peeped and from which she extracts "quotations." At least the passages are given as quotations, although upon checking them this reviewer discovered that they were paraphrases which, more often than not, misinterpreted the original. Very often the source is not mentioned beyond a vague "books say."

After observing a few specimens, or even one individual, Miss Duncan drew sweeping conclusions for entire genera, and in some cases families, although it is well known that behavior may vary even among individuals of the same species. She triumphantly records that the authorities in books do not agree with her, and that they are, therefore, wrong. Although she observed a few spiders on Cape Cod in May, a few in California in September, and the majority about which she writes during the winter months in Mexico, she frequently lumps together observations on several species or genera in the mistaken notion that they belong together. Some chapters deal with unidentified spiders for which she has invented such appellations as the Green Princess, the Baby Faun, or the Orb Cream Puff, the latter because it looks "like the white of egg that has been browned in an oven." (One wonders why the name "Meringue Spider" was not used.) However, the author must have peeped into books long enough to find scientific names for some of her subjects, although a longer look might have enabled her to spell them correctly. Often more than one letter has been omitted, e.g., *Dicta* for *Dictyna*, and sometimes extra letters are added. That these are not merely typographical errors is indicated by the fact that the misspellings are consistent throughout the volume. On one page alone six such errors occur. Names of authors are garbled, as are titles of books, and results are often credited to workers who never did what she asseverates.

As for the illustrations, she may not have *borrowed* any, but some are obviously poor copies of what have appeared in the books she scorns for their inaccuracies. Some are quite definitely not of web spiders at all, and Plate I, showing a spider's internal anatomy (which she admittedly never studied) is a model of distortion. Her original drawings are grossly inaccurate, contain imagined structures, and yet lack even such easily seen details as the correct number of leg segments. Often a drawing will reveal things in contradiction to the text. The arrangement of the illustrations is confusing, with no explanation as to which are "plates" and which "figures," though all are from pen and ink drawings. In many cases illustrations occupying only half or a third of a page (often with text on the same page) are nevertheless called "plates," while full page drawings may be called "figures." On pages 30 and 31 three independent illustrations are labeled "plates 9, 9A, and 9B," while on page 46 appear three independent illustrations over the legend "plates 13 and 14," without any clue as to which is 13, which 14, and which is unnumbered. After seeing the strange illustrations in the book, biologists in general will question the reliability of the author's observations. Many will wonder at her regular use of anthropomorphisms, for she has spiders glaring, showing ecstasy, depravity, and stupidity, being unsportsmanlike, very happy, neurotic, wild with joy, clever, contemptuous, suspicious, high-strung, pig-headed, and lacking foresight. One female "hated the sight of me" and one male "waggled his palps [the genital organs] at me flirtatiously." It is difficult to believe that this volume is in the same series with Humphrey's *Ways of the Weather*, Eberson's *Microbes Militant*, and Luhr's *Physics Tells Why*!

Miss Duncan set aside six months for the study of spiders, but found that more time was needed and so extended her researches into two years. Apparently even this was not long enough for her to learn that males do not possess an epigynum, for which she searched in vain on some specimens. Further, in describing the mating of a pair of *Tetragnatha* she mistakenly assumed that the semen was transferred by the enlarged jaws, and her drawing depicting the act completely omits the all-important palpi. The spinnerets of tarantulas are to her "mysterious horns," and the lung books are "plates . . . which cover the tracheal breathing tubes"!

The final chapter, headed General Facts, contains directions as to the collection, care, and preservation of spiders. Here we find such gems as these: "Never leave a spider in an otherwise empty jar. It will tire itself out"; and "Don't put any water in the bottom. They never drink and will sooner or later drown in it." Her directions for preserving spiders are impractical, and it is small wonder that she was unable to find certain structures on their "bloated and tangled" bodies. Because of this she is vehement in her denunciations of taxonomists who study merely "mouldering corpses on museum shelves."

Why the editor and the publishers saw fit to inflict such a volume on an unsuspecting public is incomprehensible. They would aid the humanizing of science most by suppressing the sale of such a mass of misinformation, especially as it is not unlikely that popular magazines might bring out an extract for the masses. It is to be hoped that no such example of the "blind leading the blind" will occur.

B. J. KASTON

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SPHINX. *The Story of a Caterpillar.*
By Robert M. McClung. William Morrow and Company, New York; Wm. Collins Sons & Company, Toronto, Canada. $2.00. 48 pp.; ill. 1949.

This is a simply written and effectively illustrated child's book on the development of the sphinx moth from egg to adult. The style and format are in keeping with other excellent nature stories in the Morrow Junior Series.

NORTH AMERICAN WATERFOWL.

By Albert M. Day; sketches by Bob Hines. Stackpole and Heck, New York and Harrisburg. $4.75. xx + 329 pp. + 1 plate; text ill. 1949.

Among the maze of popular bird books that pours out of publishing houses and descends on the reading public there is occasionally one that commands special attention, one that is informative, authoritative, original, and even more rarely, high readable. This is such a book. The reviewer, once started, hardly relinquished it even for such pleasurable pursuits as eating and sleeping. Not many bird books have that effect. It is authoritative because written by the Director of the Fish and Wildlife Service on a subject he is best qualified to discuss, and it is informative because what he has to say is of great importance.

His message is addressed principally to duck hunters, although other sportsmen, conservationists, ornithologists, and anyone interested in wildlife will derive much benefit by reading it. The book starts with a description of early America, the terrific toll on wildlife that occurred with the opening of the West, the slow awakening to the catastrophe that was in store, and the beginning of protective legislation. Since one purpose of this book is to explain the whys and wherefores of governmental regulations, a background of understanding of duck behavior is needed. The description of duck migration and their flyways explains why various regions of the country may have regulations that differ. The work done by the Service in order to estimate duck populations every year is carefully described in order to illustrate how bag limits and closed seasons are determined. The development of the refuge system, its importance to waterfowl, the problems of management, and the value of research are further topics discussed in such a way as to help the layman understand why such things are necessary. In considering waterfowl conservation in Canada it is pointed out how duck hunting in that relatively sparsely inhabited area offers problems that are not the same as those in this country and therefore require different regulations. The so-called "situation" in Mexico is discussed quite frankly. It is shown that the annual kill in that country is less than the kill in the United States on the opening day of the hunting season and that much of the kill south of the border is the result of illegal shooting by Americans. The final chapter points out that the ultimate fate of the wild-fowl depends on the hunters themselves and the attitude they take toward their sport. The regulations at which so many complaints are directed are only a means which without the help and cooperation of sportsmen will not in themselves save the pleasure of hunting wildfowl for future generations. On the jacket is a statement to the effect that this is not an apology from the man in Washington who directs the nation's waterfowl program, but a challenge. It remains for the wildfowling fraternity to read this book and to accept that challenge.

HENRI C. SEIBERT

BIRDS IN YOUR BACK YARD.

By Ted S. Pettit; bird drawings by George Greller; line drawings by Donald Ross. Harper & Brothers, New York. $3.00. xii + 210 pp. + 16 plates; text ill. 1949.

Those who enjoy popular bird books will probably find this one good enough to complete reading it. As the title indicates, the material is limited to backyard ornithology: how to attract and how to feed the birds, how to provide bird baths, and how to photograph them. Since entire books have been written on each of these topics, the present one cannot be considered as a complete reference work; rather, the author's attempt is to point out how bird watching can develop into an absorbing hobby. From reading the text we gather that the writer lives on Long Island; it is too bad that the text was not limited to that neighborhood. According to the jacket advertising its material is applicable from Maine to California and intervening points. To fulfil this broad coverage a chapter entitled What Bird Is That? attempts to describe garden birds over this large geographical area. The result is not very good. The species seem to have been selected without rhyme or reason, and the distinguishing features used for their identification are not aptly brought out. Thus, the sharp-shinned hawk and the Cooper hawk (backyard birds?) have identical descriptions except as to size, which is itself not a reliable field criterion. The list of plantings attractive to birds is better. The book is indexed, illustrated, and contains a short bibliography of books of general interest.

HENRI C. SEIBERT

STUDIES OF THE NESTING BIRDS OF THE EDWIN S. GEORGE RESERVE. PART I. THE VIREOS. *Miscellaneous Publications, Museum of Zoology, University of Michigan, Number 74.*

By George Miksch Sutton. University of Michigan Press, Ann Arbor. $1.00 (paper). 37 pp. + 5 plates. 1949.

Three species of vireos spend the summer on the Edwin S. George Reserve in Michigan. These are the yellow-throated, red-eyed, and warbling vireos. A comparative study of their nesting habits reveals no interspecific rivalry. The warbling vireo prefers trees bordering on wet areas and when the water level of a low-lying tract of land rises, this species establishes itself; whereas the red-eyed vireo, which prefers drier oak-hickory woodland, then disappears. The red-eyed vireo is heavily parasitized by the cowbird, whereas the other two species are not. Young males of all three species learn to sing fairly well before leaving for the south. Whether two broods are ever reared under natural circumstances in this area has not been definitely ascertained.

Since the title of this paper bears the notation Part I, we may expect further contributions on the subject. These should add considerably to our information regarding the nesting biology of many species (the most common ones, we hope). The publication contains a color plate of a young yellow-throated vireo just out of the nest, done in water color, and rendered with the delicacy and feeling of a master bird artist.

HENRI C. SEIBERT

◆

THE SANDHILL CRANES. *Bulletin Number 29.*
By Lawrence H. Walkinshaw. Cranbrook Institute of Science, Bloomfield Hills, Michigan. $3.50. x + 202 pp. + 18 plates; text ill. 1949.

The sandhill cranes are wild and wary birds, to be seen as they fly away from the approaching observer. Most of our knowledge concerning them has been pieced from fragmentary and disconnected observations. Yet here is an entire book devoted to their life history. To accomplish this feat the author has traveled more than 70,000 miles and spent 15 years studying their habits over their entire range, which spreads from Alaska to the Isle of Pines.

Four geographical races of this species are currently recognized: the lesser sandhill crane, *Grus canadensis canadensis*, which breeds in Alaska and northern Canada; the greater sandhill crane, *G. c. tabida*, breeding in southern British Columbia, Alberta, Saskatchewan, northwestern and northcentral United States east to Michigan; the Florida sandhill crane, *G. c. pratensis*, which breeds along the Gulf Coast, formerly from Louisiana east to Georgia and Florida; and the Cuban sandhill crane, *G. c. nesiotes*, which is found in western Cuba and the Isles of Pines. Size of wing and of tarsi differentiate these races; there is very little difference in plumage coloration. The second chapter discusses this size variation as well as plumage color and molt. The bathing habit of this bird causes its feathers to become dyed by various organic colors in the water. The next chapter considers the characteristic trumpeting calls of the crane, their variations, the notes of the young, the time of day and frequency of utterance. A chapter on crane behavior describes the flight, walking, and swimming activities, as well as the famous dance, which apparently is not limited to the courtship period but may occur at any time. Food and feeding habits are considered next. The cranes prefer grain and vegetable matter such as berries, tubers, etc., but will frequently eat grubs, grasshoppers, frogs, mice and other animals. Evidence for pairing and territory formation is meager, but what little there is indicates that the sandhill cranes remain paired for successive years. Each pair seems to maintain a territory, although its defense is not aggressive, since there is sufficient room available for all. Young birds returning with their parents in the spring are chased away.

A lengthy chapter on nesting includes descriptions of nest sites, clutch sizes, egg sizes, incubation periods, and the geographical and ecological distributions of all four subspecies. It is interesting to note that *G. c. tabida* lays 1.933 eggs per set on the average, whereas *pratensis* lays 1.727, in agreement with the frequently made observation that southern birds lay fewer eggs than their northern congeners. Data on *canadensis* and *nesiotes* are lacking to extend this observation. Nesting success is around 70 per cent. The female incubates during the night and both parents alternate during the day. Hatching dates become increasingly early the farther south the nesting area. Considerable information on the growth and behavior of the young was obtained from a newly hatched bird that was hand-reared by the author and which ultimately became a most fascinating pet.

Both *Grus c. canadensis* and *tabida* are migratory, wintering mostly in California, Arizona, New Mexico, Texas, and northern Mexico; the other two races are resident. A survey of the crane population reveals that *canadensis* is the most numerous, with flocks from 30,000 to 100,000 still being reported. Breeding as it does in northern wilderness areas, its future seems assured. The greater sandhill crane has been greatly reduced in numbers, since its requirements of marsh and solitude have been continually restricted by increasing human population and by cultivation of former marsh lands. Walkinshaw estimates a maximum of 1800 survivors. The Florida race seems on the increase since the creation of reserves in the Okefinokee Swamp and the Everglades. It is impossible to estimate its former abundance, but at present there are about 2650 cranes, including those in Mississippi. The Cuban race is scarce and is given little chance of survival unless adequate protective measures are taken immediately.

The odd bits of information that have just been mentioned are only fragments of the total material assembled in this book. A considerable part of the data is condensed into tables and maps. The literature has been diligently reviewed and frequently quoted. Even pertinent observations on other species of cranes are included. There are 17 plates of photographs showing the cranes, their nests, nest sites, and a series picturing the growth stages of Brownie, the pet. Appendix A provides a key to the cranes of the world. Appendix B gives complete distribution records for all races of the sandhill crane, including fall and spring migration, and winter records for the migratory forms, listed by state or territory, as well as museum specimens. This extensive record (21 pages) is followed by the bibliography for those records (11 pages). The result is a thorough compendium of existing knowledge on a little known species of bird, a book that will remain an indispensable reference for a long time to come.

Henri C. Seibert

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Homing Pigeons.

By Herbert S. Zim; illustrated by James Gordon Irving. William Morrow & Company, New York. $2.00. 64 pp.; ill. 1949

This is another of the excellent "animal monographs" by Zim. Older children (and even adults) will find many interesting details regarding the raising and performance of homing pigeons presented in this book. The text is accompanied by many good illustrations drawn by J. G. Irving. It is to be hoped that this will not be the last of this highly informative series of animal stories.

John Cushing

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Pennsylvania Birdlife. *Second Revised and Enlarged Edition.*

By Hal H. Harrison. The Pennsylvania Game Commission, Harrisburg. 50 cents (paper). 72 pp.; ill. 1948.

The Pennsylvania Game Commission is to be congratulated on the appearance of this attractive booklet. Its purpose is to create interest in and to secure help for the protection of birdlife. The following topics are considered: the value of birds; how to attract birds (bird houses, feeding, planting); how to study birds (field observations, banding, photography); conservation of birds (refuges, permits, control); interesting things about birds (a random list of questions and answers plus some bird facts and fallacies); a check-list of Pennsylvania birds; and a thumb-nail sketch of 50 common birds. Since the booklet contains only 71 pages, half of which are taken up by illustrations, it must be obvious that the topics are discussed very briefly. Nevertheless, the aims for which the booklet was published are successfully accomplished; such authoritative propaganda is to be recommended.

Henri C. Seibert

Pennsylvania Birds of Prey.

By Robert D. McDowell and Leo A. Luttringer. Pennsylvania Game Commission, Harrisburg. 25 cents (paper). 33 pp. + 4 plates; text ill. 1948.

If we may borrow from the introduction: "The purpose of this little pamphlet is not to praise or to condemn the birds of prey, nor to further agitate the age-old controversy concerning their good and bad habits. The object is to show people how to identify them and to understand in a general way the part they play in the scheme of nature." To accomplish this purpose, keys to the species of hawks and owls, as well as colored illustrations, are provided for their identification. Each bird of prey is allotted a page for brief remarks on its status and nesting habits. In the corner is a sectorial graph showing clearly the type of food consumed and its proportion to the total diet. Anyone reading this material with an unbiased mind should quickly get the hint that the majority of the birds of prey are more beneficial than harmful. This booklet should be given widespread distribution and made easily available to the public.

Henri C. Seibert

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Wild Life the World Over.

By E. G. Boulenger, A. Radclyffe Dugmore, Walford B. Johnson, Oliver G. Pike, Horace Donisthorpe, F. Martin Duncan, Ray Palmer, Leo Walmsley, and David Seth Smith. Wise & Company, New York. $3.95. 624 pp. + 8 plates; text ill. 1947.

This is quite as fine a natural history of animals as one may find in a single volume. It is distinguished not only for its interesting text, written by a group of well-known naturalists, most of whom are British, but also for its wealth of superb photographs of wild animals. Included, besides the customary groups of mammals, are the chapters A World Survey of Bird Life, Lizards and Snakes, Crocodiles and Other Reptiles, Marvels of the Insect Kingdom, Tiny Creatures of Pond and Stream (protozoa, aquatic insects, frogs and salamanders), Living Fossils of the Sea (sponges, coelenterates, annelids, echinoderms, mollusks, etc.), Fish, their Nature and Habits, and, finally, The March of Evolution. This is an extraordinarily good bargain at the price quoted, and will make a fine gift for any young naturalist.

Bentley Glass

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The Farmer and Wildlife.

By Durward L. Allen. Wildlife Management Institute, Washington, D. C. 30 cents (paper). 84 pp.; ill. 1949.

This attractively printed pamphlet is aimed directly at the farmer. In non-technical language it persuasively explains why wildlife should be encouraged on the farm, what the farmer can expect from it, and how he can go about making his property attractive by creating brushpiles, fence-rows, field borders, ponds, and other improvements. The principal argument is based on the idea respecting land use that wise and profitable farming goes hand in hand with the presence of wildlife and that only rarely are the two competitive. In accordance with the latest concepts of management, suitable habitat is stressed, with food of secondary importance, and stocking and predator control relegated to the category of the useless. Numerous illustrations of game and habitat improvements, plus some amusing drawings by Oscar Warbach, make this publication an especially well conceived and executed project, one that should do much to spread the good word to the farmers upon whom the major success of wildlife management depends.

HENRI C. SEIBERT

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VISON, THE MINK. *American Woodland Tales.*

By John L. George and Jean George. E. P. Dutton & Company, New York. $2.50. 184 pp.; ill. 1949.

Like *Vulpes the Red Fox* (Q.R.B. 24: 59, 1949), *Vison, the Mink* is a fine example of the personalized life story of an animal. From the days of blind kithood in the deeply tunneled den beside the stream to that night, seven years later, when the crafty and battle-scarred veteran swam dauntlessly to his last battle with a younger and now stronger usurper (his own son), Vison's life is portrayed both with realism and poetic feeling. Not the least attractive feature of the book is the wealth of beautiful drawings by Jean George. Here is a perfect gift for the young naturalist of high school age.

BENTLEY GLASS

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NATURE AND ITS APPLICATIONS: *Over 200,000 Selected References to Nature Forms and Illustrations of Nature as Used in Every Way. Useful Reference Series, Number 74.*

Compiled by Jessie Croft Ellis. The F. W. Faxon Company, Boston. $17.00. xii + 861 pp. 1949.

This index will be an exceedingly useful tool for those teachers of biology who wish to find references to the more popular articles on subjects of natural history, and particularly to find good illustrations. The extent of the index may be gathered from the fact that even the agouti rates 9 references, while those on the horse, with many subheadings, fill 29 pages. Although some scientific names are indexed, the majority of the terms indexed are common names. The high price of the volume will probably limit it to general libraries, where it is to be hoped it will be universally available.

BENTLEY GLASS

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OBSERVATIONS ON THE PLANT COMMUNITIES AT "BUNDEMAR," TRANGIE DISTRICT, NEW SOUTH WALES, IN RELATION TO CHORTOICETES TERMINIFERA (WALK.) AND AUSTROICETES CRUCIATA (SAUSS.). *Council for Scientific and Industrial Research, Commonwealth of Australia. Bulletin Number 236.*

By L. R. Clark. Council for Scientific and Industrial Research, Melbourne. Free upon request (paper). 64 pp. + 5 plates; text ill. 1948.

EVOLUTION

THE MEANING OF EVOLUTION. *A Study of the History of Life and of Its Significance for Man. The Terry Lectures.*

By George Gaylord Simpson. Yale University Press, New Haven; Geoffrey Cumberlege, Oxford University Press, London. $3.75. xvi + 364 pp.; ill. 1949.

These lectures, which throughout show the author's keen feeling for beauty as well as precision of language, fall into three distinct parts. The first section of the book deals with The Course of Evolution. In the brief span of 120 pages, Simpson has given us perhaps the best existing sketch of the geological history of life. For those who found *Tempo and Mode in Evolution* overly technical and difficult, nothing better can be recommended than this outline. The second part of the book deals with The Interpretation of Evolution. Simpson's emphatic disposition of orthogenesis and his discussion of the nature and significance of trends will not surprise any readers of his earlier book, but there are still many students of evolution who need to have the weakness of the evidence for orthogenesis pointed out. Those who still refer to the evolution of the horse, in particular, as a clear-cut example of an orthogenetic trend in evolution ought by all means to be referred to these chapters. Simpson not only stresses the fact that "adaptation has a known mechanism: natural selection acting on the genetics of populations"; he goes much farther in showing that there is no need to postulate intrinsic forces of racial life, senescence, and death, and that evolution is essentially "opportunistic," in the sense that random variations may yield "multiple solutions of adaptational problems." This may be seen on the one hand in the evolutionary appearance of various superficially similar sorts of image-forming eyes, and on the other in the parallels of adaptive radiation seen when "the same sorts of opportunities have occurred for different groups of animals."

The chapter on the Forces of Evolution and their Integration seems to be rather less adequate to its purpose than the others. Perhaps this is because so vast an array of genetic concepts has been compressed here into so small a compass. The treatment is too general and, it would appear, takes too much for understood on the part of the audience. Those who find the treatment obscure may welcome the far more explicit treatment of the genetics of populations given in Chapter II of *Tempo and Mode in Evolution.*

The discussion of The Concept of Progress in Evolution, together with an interesting, if all too brief, historical study of the development of the theory of evolution, provides an excellent transition to the third part of the book, which deals with Evolution, Humanity, and Ethics. Simpson holds that:

> "evolution is not invariably accompanied by progress, nor does it really seem to be characterized by progress as an essential feature. Progress has occurred within it but is not of its essence. Aside from the broad tendency for the expansion of life, which is also inconstant, there is no sense in which it can be said that evolution *is* progress. Within the framework of the evolutionary history of life there have been not one but many different sorts of progress. Each sort appears not with one single line or even with one central but branching line throughout the course of evolution, but separately in many different lines. These phenomena seem fully consistent with, and indeed readily explained by, the materialistic theory of evolution sketched in the last chapter. They are certainly inconsistent with the existence of a supernal perfecting principle, with the concept of a goal in evolution, or with the control of evolution by autonomous factors, a vital principle common to all forms of life.... To man, evolutionary change in the direction of man *is* progress.... It is not progress in a general or objective sense and does not warrant choice of the line of man's ancestry as the central line of evolution as a whole. More general and objective criteria of progress are available and corresponding sorts of progress exist in the history of life. These, too, fail to designate man's ancestry as a central line, and indeed fail to reveal any one such line. A majority of them do, however, show that man is among the highest products of evolution and a balance of them warrants the conclusion that man is, on the whole but not in every single respect, the pinnacle so far of evolutionary progress." (pp. 261–262).

In the search for an ethic, Simpson avoids the fallacy of "nothing but" (an animal) in estimating man's place in nature. "Man," he opines, "is a moral animal." This allows him to search for a basis of ethics, not so much in man's nature as an animal product of evolution, which must lead to a simple survival ethic—"what best promotes survival is good"—but rather in the unique qualities of man as a social being, with "conscious knowledge, purpose, choice, and values [that] carry as an inevitable corollary responsibility." The new evolution, peculiar to man, involves the spread and "inheritance" of knowledge. Seen in this light, authoritarianism and totalitarianism must alike be wrong, while democracy, although wanting in many respects, offers the only ethically good society. Like Hogben (see review of *The New Authoritarianism,* p. 200 of this issue), Simpson would appear to arrive at Muller's conclusion that along with intellectual freedom for all men there must go hand in hand the education and elevation of the standard of living of all men everywhere, so that the heritage of knowledge and power will belong to the many rather than to the few. Simpson puts it this way: "One thing that is definitely known now is that breeding for uniformity of type and for elimination of variability in the human species would be ethically, socially, and genetically bad and would not promote desirable evolution" (p. 335). "We need to remember that cultural evolution proceeds only by interthinking, as organic evolution does by interbreeding. The most brilliant of geniuses is an intellectual eunuch if his knowledge is not disseminated as widely as possible. It is immoral for any man, industry, or nation to reserve knowledge for its own advantage alone" (p. 337). The alternative for our species is self-extinction. For better or worse, man now holds within his hands the possibility of either directing evolution or ending it altogether. Nec temere, nec timide.

Bentley Glass

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Bibliography and Index of Geology Exclusive of North America. *Geological Society of America. Volume 13—1948.*

By Marie Siegrist and Eleanor Tatge. Geological Society of America, New York. $3.25. xii + 386 pp. 1949.

Another volume in what continues to be the best serial index of any body of scientific literature. When will we have more of the like, to cover the biological fields?

Bentley Glass

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GENETICS AND CYTOLOGY

The Yeast Cell. *Its Genetics and Cytology.*

By Carl C. Lindegren. Educational Publishers, Saint Louis. $7.00. xviii + 365 pp.; ill. 1949.

C. C. Lindegren is to be commended for a summary of some of the recent developments in studies on the genetics and cytology of yeast. A major portion of the book is devoted to presentations of the author's original publications. In so doing, Lindegren has, to some extent, slighted the very considerable genetic work of the Carlsberg group (Winge, et al.), and the cytological studies of investigators like Subramanian and DeLamater.

Some of the subjects included in the book are: Sporulation and Conjugation, Staining Techniques, Cytology, Microdissection (of yeast asci), and Regular and Irregular Genetic Ratios in Tetrad Analysis. Techniques in use in the author's laboratory for carrying out genetic investigations with yeast are presented in some detail, and constitute a very valuable part of the book. The author's view of the nuclear cytology of the yeast cell, viz., that the "vacuole" is the "nucleus," is still a subject of controversy in many quarters, and so must be taken with reserve. Lindegren presents data on the irregular segregation of a number of genes, which he feels cannot be reconciled with currently accepted views on genetics. To explain these occurrences, he has proposed the theories of "depletion mutations" and "conversions," the essential feature of which is the transfer of material from gene to gene in the heterozygote. These new theories of Lindegren must await further critical research for substantiation.

There are a number of typographical errors in the text and in the bibliography, and several of the references in the text are not included in the bibliography. There is no subject index. The book is rather specialized for the general biologist, but should be profitable and stimulating to the research worker in genetics.

SEYMOUR POMPER

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CELLULA. *Tabulae Biologicae, Volume XIX, Part 3.*

Edited by H. Handovsky. W. Junk, Den Haag. Dutch guilders 60.00 ($15.85) (paper). xvi + 316 pp.; ill. 1948.

Largely prepared in 1940, but delayed in publication by the past war, Volume XIX is essentially a compilation in tables of quantitative experimental data in a number of biological fields. The topics covered are as follows: Heat production in different cells (Shapiro); Ermittlung submikroskopischer Strukturen (Frey-Wyssling and Blank); Actions des radiations sur les cellules et les tissus (Dognon and Biancani); Cell metabolism (Krebs and Johnson); Constantes physicochimiques des colorants, utilisés dans l'étude des cellules (Lison and Fautrez); and Vergleichende Chemie pflanzlicher Zellen (Froeschel). Much of the information, with the exception of that by Frey-Wyssling and Blank, dates before 1940, and is consequently, in some instances, outmoded by more recent findings. The specialized worker in these fields, however, will find the tabulated material quite useful.

C. P. SWANSON

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HYBRID CORN (MAIZE) IN THEORY AND PRACTICE.

By Gordon Haskell. The Biological Press, London. 5s. or $1.00 (paper). 23 pp. 1949.

The United States is the only nation of the world which has fully explored the enormous possibilities of hybrid corn as an agricultural product, despite the fact that its proved worth has been known for some fifteen years. Other nations, however, are becoming aware that hybrid corn offers a partial solution to the ever-present food problem, and in England steps are being taken to obtain inbred lines which can be satisfactorily crossed for improved yields. The author is associated with this project, and in this brief address to the British Association for the Advancement of Science he outlined the history and methods of hybrid corn production, discussed the basis of heterosis, and considered the possible value of a breeding program for the British Commonwealth. It is a concisely written but informative pamphlet.

C. P. SWANSON

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GENETICS OF THE FOWL. *McGraw-Hill Publications in the Agricultural Sciences.*

By F. B. Hutt. McGraw-Hill Book Company, New York, Toronto, and London. $6.50. xii + 590 pp.; ill. 1949.

A book such as the present one has been long overdue. Much of the literature on poultry genetics has been published in journals and bulletins which are not easily accessible, and all too little effort has been made by many authors to give critical reviews of the work done by their predecessors. Hutt's book is primarily designed to meet the needs of courses on poultry genetics and to provide other geneticists and biologists generally with a critical digest of the available information. It may be said at the outset that both purposes have been met admirably.

The 15 chapters of the book deal with the following subjects: the phylogeny and origin of breeds; cytology; variations in the skeleton; structural variations of the skin; structure, distribution and growth of feathers, and hen feathering; skin color; plumage color; lethal genes; variations in body size; egg production; variations of eggs in size, shape, structure and composition; disease resistance; reproductive factors, such as fertility, embryonic mortality, sex ratio, sex dimorphism, sex reversal, and mosaics; linkage groups; aspects of practical poultry breeding. The book closes with a list of symbols of the genes of fowls, a glossary of genetical terminology, and satisfactory indices.

The developmental and physiological aspects of hereditary traits are briefly discussed in each instance, and the interested reader will find in the bibliographies of each chapter an excellent guide to the pertinent literature. It seems to the reviewer that the chapters on reproductive factors are especially satisfactory because here the author has succeeded, without going into controversies over the many over-optimistic and unjustified claims abounding in the literature, in giving an exceptionally clear account of what is known beyond dispute.

A comparison of Hutt's book with Punnett's *Heredity in Poultry* (1923) shows that not a little has been accomplished in the intervening quarter century. Yet, in a wider sense, the present book should serve as a very strong indictment of the lack of sympathy, understanding, and support which, chiefly on the part of our Agricultural Experiment Stations, is responsible for the deplorably slow rate of progress of genetic studies with fowl. One may entertain the scant hope that, beyond its immediate purposes, Hutt's book will contribute to a more general understanding of the inexcusably wide and apparently ever widening gap separating "theoretical" and "applied" genetics.

WALTER LANDAUER

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LEBER'S DISEASE. *A Genealogic, Genetic and Clinical Study of 101 Cases of Retrobulbar Optic Neuritis in 20 Danish Families. Opera Ex Domo Biologiae Hereditariae Humanae Universitatis Hafniensis. Volume 10.*

By Ruth Lundsgaard. Gyldendalske Boghandel, Copenhagen; Ejnar Munksgaard, Copenhagen. Kr. 25.00 (paper). 306 pp.; ill. 1947.

Leber's disease is an uncomplicated bilateral retrobulbar neuritis appearing predominantly (85%) in males after puberty and culminating in the course of some weeks or months in a stationary loss of central vision and optic nerve atrophy. Peripheral vision is retained, so that complete blindness does not ensue. The disease is definitely inherited, and early authors were led, because of the great excess of affected males, to postulate sex-linkage. However, the fact that about 16% of those affected are females, and the fact that with a few questionable exceptions an affected male has not been known to transmit the disease to his grandsons have led some investigators to various modifications of the theory of the sex-linked inheritance of the disease, whereas others have proposed theories based on autosomal or even cytoplasmic inheritance.

Lundsgaard, in another of the studies sponsored by the Institute of Human Genetics of Copenhagen University, has undertaken an extensive clinical and genetic investigation of all the cases of Leber's disease occurring in recent years in Denmark. A particular effort has been made to trace possible relationships between the various Danish families in which the disease has been reported. This has involved extensive recourse to various public and medical records. From these efforts there have resulted 20 pedigrees, several quite extensive, plus 5 isolated cases. The author is to be complimented on the completeness of her genealogical studies. The pertinent clinical data on the diagnosis and course of the disease, and the findings of previous investigators, are also treated in detail.

Lundsgaard's data reveal the usual marked excess of affected males. She finds that nowhere in her data or in those pedigrees which she is willing to accept from the literature is there any evidence that an affected male has transmitted the condition to his grandsons, an essential prerequisite of sex-linked inheritance. She postulates, therefore, that the disease is due to an autosomal gene with complete or nearly complete dominance in the male but very incomplete dominance in the female, with the further condition that the gene is lethal to all spermatozoa which receive it. A somewhat similar theory was proposed by Komai in 1934.

This genetically complex and ingenious hypothesis merits careful scrutiny. It appears to provide a formal explanation for the observed facts. The author's own crucial data are derived from a single extensive family, summarized in Pedigree A. It is stated that of 7 grandsons of certainly affected males, and 4 of probably affected males, none developed Leber's disease. It is unfortunate that these critical lines of descent are not clearly indicated on the pedigree in question, nor was the reviewer able to find data on the age of the unaffected grandsons—an extremely important point when one is concerned with a disease so variable in its age of onset. Certain confirmatory data are cited from the literature, but part of these appear open to the same criticism regarding the age of the unaffected grandsons. The reviewer does not mean to imply that the point is invalid, but rather that it is not possible from the presentation to form an objective opinion as to the degree of validity. An unrelated objection to this hypothesis, of an entirely theoretical nature, is the fact that there is little evidence from the extensive investigations of infra-human material that genes contained in spermatozoa are physiologically active. Although there are bound to be exceptions to this rule, the fact remains that they must be uncommon.

The author's conclusions would be strengthened by further data relating to the above-discussed grandsons. It is greatly to be hoped that follow-up studies will be carried out and that the results will be added to these extensive pedigrees. Even without this addition, however, the monograph must be accounted a very significant contribution to a complex problem in human inheritance.

JAMES V. NEEL

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HEREDITY IN HUMAN LEUKEMIA AND ITS RELATION TO CANCER. *A Genetic and Clinical Study of 209 Probands. Opera Ex Domo Biologiae Hereditariae Humanae Universitatis Hafniensis. Volume 13.*

By Aage Videbaek. Arnold Busck and Ejnar Munksgaard, Copenhagen; H. K. Lewis, London. Kr. 15.00 (paper). 279 pp.; ill. 1947.

The author reports the results of an extensive study on heredity in human leukemia, together with a review of the available literature on the subject. The starting point for the investigation was a material of

310 persons for whom a diagnosis of leukemia had been made between the years 1936 and 1945 in the greater Copenhagen (Denmark) area. It was possible to obtain accurate data on the family histories of a representative group of 209 of these individuals. The control material consisted of 200 normal persons. For both the control and the leukemic groups, an attempt was made to determine the morbidity of leukemia and other forms of cancer in parents, grandparents, paternal and maternal uncles and aunts, brothers, sisters, and children. There were 4041 relatives in these categories for the leukemia material, and 3641 for the controls. Seventeen of the leukemic patients were found to have some relative with leukemia, yielding a minimum "familial incidence" of 8.1 per cent; only one case of leukemia was discovered among the relatives of the controls. The familial cases followed no simple genetic pattern. There was no apparent tendency for the same type of leukemia (myelogenous, lymphocytic, acute or stem-cell) to occur within a family in which there were multiple cases. The author concludes, therefore, that from the genetic standpoint the three above mentioned types of leukemia may be considered as a single entity, with the tendency to develop the disease depending on "chromosomal inheritance," possible "failing dominance," possibly "polymeria." There is some evidence to suggest that all forms of the disease are diagnosed earlier in families in which there are multiple cases than in families in which the case is an isolated occurrence. One or more cases of pernicious anemia were observed in 17 of the 209 families for which the proband was a person with leukemia, but in only 6 of the 200 control families, from which it is concluded that there is a significant tendency for leukemia and pernicious anemia to be associated in the same family. Diabetes, hyperthyroidism, and hypothyroidism did not have any higher incidence in leukemic individuals and their relatives than in the control material.

Among the 4041 relatives of the 209 leukemic patients, the diagnosis of cancer had been made in 319, while among the 3641 relatives of the control probands there were 218 diagnoses of cancer, the difference being significant and present in all categories of relatives. The increased cancer incidence among the relatives of leukemics did not appear to be restricted to any particular type of cancer. It is stated that the cancer risk—"the probability of the relative in question getting cancer if he lives through all the age classes in which it is possible to get cancer"—is the same for all types of leukemia, varying from 23 per cent in paternal aunts to 48 per cent in fathers, with an average of 31 per cent, whereas in the control material the average is 21 per cent. It is felt that the data suggest that there is a dominant gene common for all the different forms of cancer. The author postulates that the development of leukemia in any individual depends on a variety of factors, including a non-specific hereditary predisposition to cancer, which is believed to be present in at least 20 per cent of the population, and the presence of one or several genes, the activity of which plays a role in the localization of cancer to the leukon.

The data which the author presents are extensive and apparently of high validity. His case for an increased familial incidence of leukemia and other forms of cancer among the relatives of leukemics appears sound. The reviewer's only reservation concerns the inevitable question of the strict comparability of the control material; no significant discrepancies are readily apparent. The promulgation of a precise genetic theory to account for the observed facts may impress some as premature, yet to the extent that this serves as a point of departure for further discussion and investigation it performs a valuable service, regardless of the final verdict concerning its validity.

JAMES V. NEEL

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DICTIONARY OF GENETICS *Including Terms Used in Cytology, Animal Breeding and Evolution. Lotsya—A Biological Miscellany, Volume 2.*

Compiled by R. L. Knight. Chronica Botanica Company, Waltham, Mass.; Stechert-Hafner, New York. $4.50. xii + 183 pp. 1948.

The production of this dictionary of genetics was a vast labor which all biologists will surely, in spite of its minor faults, regard as wholly praiseworthy. To quibble over a few faulty definitions, most of which, like the definition of "orthoploid," are simply too narrow in failing to indicate all the current uses of the term, would be grossly unfair. It should be a personal obligation of every geneticist and cytologist to refer to the author suggestions for the correction and improvement of the definitions given and for the inclusion of other terms. To Knight himself we can only render gratitude for doing what many would regard as a thankless task, but which all will recognize as a most valuable contribution, now that it has been made. Among the useful features of the book are its several appendices, which contain such information as useful statistical formulae, coefficients of the expansion of $(1 + x)^n$ from 1 to 20, values of 2^n and 4^n for values of n from 3 to 20, a table of χ^2, genotypes expected in backcrosses and in F_2, percentages of homozygotes following selfing up to F_{13}, the rate of elimination of a donor genotype by backcrossing, and the International Rules for Symbolizing Genes and Chromosome Aberrations, etc.

BENTLEY GLASS

GENERAL AND SYSTEMATIC BOTANY

INTERNATIONAL RULES OF BOTANICAL NOMENCLATURE. *Formulated by the International Botanical Congresses of*

Vienna, 1905, Brussels, 1910, and Cambridge, 1930; Adopted and Revised by the International Botanical Congress of Amsterdam, 1935. Unofficial Special Edition Issued as a Service to Members of the American Society of Plant Taxonomists. Brittonia, Volume 6, Number 1, 1947.

Compiled from various sources by W. H. Camp, H. W. Rickett and C. A. Weatherby. The Chronica Botanica Company, Waltham, Massachusetts. $3.50. Pp. 1–120. 1948.

In March 1946, at a meeting of the council of the American Society of Plant Taxonomists, a committee on nomenclature was formed to begin preparing agenda for the next International Botanical Congress. It soon became clear that before this could be done, it would be necessary to prepare a clear statement of the existing international rules of botanical nomenclature. Copies of the last edition of these rules (1935) were no longer available, and emendations to them made later in 1935 were not readily available to many American students. The committee, therefore, has compiled the existing rules in a single volume, which they say is not to be regarded in any sense as an official edition, although it is taken from authentic sources. As appendices they have included lists of *nomina conservanda* and an index to the plant names appearing in the lists of conserved generic names. The book ends with a general index.

Originally published in *Brittonia*, the publication now appears in a "second printing," reproduced by offset lithography. To institutions and individuals concerned with taxonomic research, it will be a valuable tool.

H. M. Raup

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The Essentials of Plant Biology.

By Frank D. Kern. Harper and Brothers Publishers, New York and London. $4.00. viii + 440 pp. + 6 plates; text ill. 1947.

The subject matter in this elementary textbook has been divided into two major categories: the maintenance of individual life, and racial preservation. When it is considered that these two rather inclusive topics are encompassed in a book designed for a one-semester course in botany, it is readily understandable that no single phase of the science can receive other than a most cursory treatment. The chapter on plant anatomy is probably the most completely written and illustrated. Nutrition and physiology are presented in a most elementary fashion, e.g., only three very simple chemical reactions are presented. Meiosis is considered in a page and a half plus one incorrect diagram, although the author stresses the fact that "the whole process of meiosis must be understood because it affords the basis of the genetic phenomena to be discussed later." Crossing over is disposed of by the statement that "it is reported that linkage is not perfect."

The book, therefore, although well written and illustrated, can scarcely be considered the equal of other similar volumes. It can be recommended, however, for those students who must take a required course in the natural sciences—it will not overtax them.

C. P. Swanson

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Studies in Plant Life. *Second Edition.*

By Harvey E. Stork. Burgess Publishing Company, Minneapolis. $3.00 (paper). vii + 115 pp.; ill. 1949.

Laboratory Exercises; Biology of Plants.

By H. L. Dean. Wm. C. Brown Company, Dubuque, Iowa. $2.25 (paper). vi + 265 pp.; ill. 1949.

Laboratory and Field Exercises in Botany.

By Fred W. Emerson and Lora Mangum Shields. The Blakiston Company, Philadelphia and Toronto. $2.50 (paper). xii + 303 pp.; ill. 1949.

Workbook in Fundamentals of Plant Science.

By George B. Cummins and George A. Gries. Burgess Publishing Company, Minneapolis. $2.00 (paper). iv + 121 pp.; ill. 1948.

Laboratory Problems in Plant Science.

By George B. Cummins, George A. Gries, Jesse H. Lefforge and Forest W. Stearns. Burgess Publishing Company, Minneapolis. $2.00 (paper). iv + 112 pp.; ill. 1948.

Prepared laboratory manuals in botany can be had for almost any type of course. Most are designed to meet the needs of particular courses given by their authors, but the requirements of almost any beginning botany course can be met by one or another of the many manuals currently available. The current crop reflects this diversity. Those by Stork and Dean, respectively, are semi-textbooks, on the whole well written and reasonably illustrated. The manual by Emerson and Shields is a laboratory accompaniment to Emerson's excellent *Basic Botany.* That by Cummins and Gries is particularly poor, and any resemblance between their drawings and actual plant materials is pure coincidence.

Laboratory manuals are obvious time-savers for both students and teachers, but one is led to wonder whether a student acquires what he should from this sort of teaching device. Rapidity of training is fast becoming a goal in itself, and the encouragement of curiosity seems noticeably missing. There can be little doubt that part of the lack of enthusiasm for botany among students stems from the mechanical introduction to the science which these manuals represent.

C. P. Swanson

CONTRIBUTIONS DE L'INSTITUT BOTANIQUE DE L'UNIVERSITÉ DE MONTRÉAL. *Nouvelles Études Taxonomiques sur la Flore de Cuba. Number 63.*

By Frère Marie-Victorin. Université de Montréal, Institut Botanique, Montréal. 50 cents (paper). 77 pp.; ill. 1948.

This contribution consists of six posthumous papers prepared by Frère Marie-Victorin before his death in 1944. They are additional material to Contribution No. 49, published in 1944 by Frère Marie-Victorin and Frère Léon of Havana. The present volume has an explanatory foreword by Jules Brunel. Nineteen new entities are described, consisting of 15 new species and 4 new varieties. First is a review of the genus *Hedyosmum*, with a key to the species and a description of 1 new species, *H. leonis*. The second paper is a treatment of the genus *Belotia* in Cuba, and contains one nomenclatural change; *B. lessertiana* Hochr. is reduced to a variety of *B. grewiaefolia*. The third paper is a revision of the genus *Spathelia*, with a description of 5 new species and 1 new variety. The genus *Purdiaea* is revised in the fourth paper with descriptions of 4 new species and 3 new varieties. The remaining two papers treat the genus *Ravenia*, with 3 new species, and contain a description of a new species of *Sabbatia*. The papers are amply illustrated with photographs.

H. M. RAUP

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CONTRIBUTIONS DE L'INSTITUT BOTANIQUE DE L'UNIVERSITÉ DE MONTRÉAL. *Number 64, March 31, 1949.*

Institut Botanique, Université de Montréal, Montréal. 50 cents (paper). 83 pp.; ill. 1949.

Contribution 64 consists of seven papers, all concerned primarily with taxonomic and floristic studies in eastern Canada. The following is a list of the contents: The rediscovery of the Desmid *Pleurotaenium spinulosum*, with description of a new variety from Madagascar (Jules Brunel); *Achroonema spiroideum* Skuja 1948, of the Trichobacteriales, discovered simultaneously in Sweden and in Canada (J. Brunel); Le genre *Elatine* dans le Québec (Roger Gauthier and Marcel Raymond); Notes sur le genre *Carex*. II. La valeur taxonomique de *C. arctogena* (M. Raymond); Notes sur les *Arisaema* du Québec, (M. Raymond); Quelques Muscinées des iles de la Madeleine, (James Kucyniak); Enumeratic plantarum vascularum Terrae Novae, (Ernest Rouleau).

H. M. RAUP

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ATLAS POUR LA DÉTERMINATION DES DIATOMÉES.

By P. Lefébure. Laboratoire de Micrographie, Paris. 300 fr. (paper). 80 pp.; ill. 1947.

Thirty-one plates illustrating and identifying diatoms, with a table of genera but no keys.

THE ALGAL GENUS GRACILARIA IN AUSTRALIA. *Division of Fisheries—Report Number 15. Council for Scientific and Industrial Research, Bulletin Number 235.*

By Valerie May. Council for Scientific and Industrial Research, Melbourne. Free upon request (paper). 64 pp. + 15 plates; text ill. 1948.

A taxonomic study of the 9 species of the genus *Gracilaria*, most used in Australia for agar production Six new forms are described.

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NATURAL HISTORY OF THE DANISH LICHENS. *Original Investigations Based Upon New Principles. Part I–VII.*

By Olaf Galløe. (I–IV) H. Aschehoug & Co., Copenhagen; (V–VII) Einar Munksgaard, Copenhagen. Dan. Kr. 40.00 each (paper). (I) 93 pp. + 160 plates. 1927; (II) 84 pp. + 128 plates. 1929; (III) 114 pp. + 127 plates. 1932; (IV) 81 pp. + 133 plates. 1932; (V) 117 pp. + 140 plates. 1936; (VI) 103 pp. + 88 plates. 1939; (VII) 62 pp. + 101 plates. 1948.

Lichenologists, particularly the English-speaking group, should consider themselves fortunate in having available the seven completed parts of this proposed 10-volume work. The 592 pages of English text are supplemented by 2,977 black and white drawings water colors, and some color photographs on 776 plates. The quality of the paper, the large type, and the beautifully reproduced illustrations reflect well the generosity of the Carlsberg Foundation, which has sponsored Galløe's studies. The last two volumes will consist of a general survey of the taxonomy and natural history of Danish lichens; an index to genera and species would make the material more readily available.

Although the title would imply a local survey of Danish lichens, the treatment itself considers genera and species having a wide, north temperate distribution; hence the work has a more general application. The style is monographic, although the author does not cite synonymy; he admits that much of the basis for his species conception is contained in Th. Fries' *Lichenographia Scandinavica*. The handling of some 60 genera and numerous species is also unique in that the author presents a detailed morphological and anatomical analysis of "typical, selected and representative" individual specimens to give a concept of the particular species instead of conventionally citing types. Thus, *Lobaria pulmonaria* is given with detailed description and drawings of six specimens. He suggests this as a means of gaining a better conception of a species in the absence of type material. Galløe's early suggestion, in Volume One, for the development of an International Institute for type specimens would not be too willingly accepted by most taxonomists with our present-day realization of what has happened to the plant collections stored in bombed-out European cities.

With each genus Galløe gives a statement of the phylogeny. Species treatment consists of a full, expert description supplemented by numerous detailed illustrations of the internal thallus anatomy, apothecia, spores, and gross morphological features, of which one can only quote the late Lynge's critical remark:—"Galløe's figures are excellent as they always are." With the exception of a local citation, no floristic data are presented, for, as the author clearly states, this is not a floristic study but a natural history survey. Neither are chemical reactions given, for the author rightfully considers the interpretation of these reactions as 'disputable'." To students in lichenology, to cryptogamic botanists with little knowledge of lichens, and to the non-professional botanist, the natural history of the Danish lichens makes available a wealth of information to those seeking definite answers regarding the morphology of lichen genera; it will serve admirably for the identification of species or as an introduction to the interesting science of lichenology. This is an excellent treatment of a generally ignored branch of cryptogamic botany.

George A. Llano

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Les Champignons. *Tableaux d'un Monde Étrange.*
By Roger Heim; photographs by Jean Vincent; illustrations by Yvonne Jean-Haffen. Éditions Alpina, Paris. 2200 fr. (paper). 143 pp. + 6 plates; text ill. 1948.

This book appears to be intended for those intelligent persons who lack a special training in mycology but who are, or may be led to become, interested in the fungi which lie before them wherever they may go. The author indicates that the subject of mycology may be at the same time a sport, a science, and an art. The proper study of fungi involves personal visits to their natural habitats, learning where and when to find them and, having learned to know them, the faculty of remembering what they are and for what reasons they are of special interest. Heim gives careful advice which, if followed, will aid the would-be mycophagist to find and recognize dangerous species first and then gradually the safe ones, beginning with those most easily detected and distinguished from the poisonous sorts, and then proceeding to the recognition of most of the fungi that may be made use of. Translating from the author: "Once the worst species are known, the mycophagist will penetrate gradually among those which merit his confidence for the kitchen. He will approach them with prudence, with method, progressively, commencing not with the best but with those which one can characterize best in a limited category. He will reject all those eminently dangerous rules of thumb which are current in the country and elsewhere: the piece of silver that blackens, the onion that turns brown, the flesh that becomes blue, etc." He criticizes the difficulties caused in most books by too technical an approach to the subject, as well as by the reluctance of the masters of the subject to give their time and effort to write about it accurately but in words that the layman can comprehend.

The main chapters are: The Fungi of April, *Russula* and *Lactarius*; From the Clavarias to the Polypores; The Boleti; The Fungi Which Gleam (including a brief discussion of luminous fungi as well as those which shine when their viscid coat becomes wet by rain or dew; The Agarics; The Gasteromycetes; The Destroyers (fungi injurious to plants); Insects and Fungi; A Visit to the Laboratory (to see fungi under culture); The Healers (antibiotics); and finally, an Invitation for a Field Trip. This part is followed by a Summary Table of the general classification of fungi and by a Key for determining the European genera of Gill Fungi, and a Key to the European genera of Basidiomycetes growing on dead or dying wood (mostly the Heterobasideae and Aphyllophorales). Each chapter presents a short general discussion and then is illustrated by marvelous photographs of the more important species, each with a description in non-technical terms of their most distinctive characters. Notes are given as to their safety or danger when eaten. Such notes, however, are not always given in these separate descriptions, but are included in the general text or even in the introductory chapter. In criticism, the reviewer wishes that a list had been given of all the species illustrated, with emphasis on their safety or danger as food. The six colored plates are from water-color sketches which lack the finer details but show well the forms and colors.

In this book, intended mainly for the general public, the author does not indulge in the extensive genus-splitting that is now becoming the style among some modern mycologists, but gives the older, more familiar names. Each species illustrated is discussed under its French name, although the Latin name (without author citation) is given for each uncolored figure. The size of the book (10 × 9 inches) and its paper binding will prevent its being used extensively for field trips, but its careful perusal can not fail to stimulate and help intelligent persons who read it before and after making such trips. Although intended primarily for France and adjacent regions, the fact that most of the species illustrated occur even in America will make the book well worth possessing in this country.

Ernst A. Bessey

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Poisonous Fungi. *The King Penguin Books.*
By John Ramsbottom; with colour plates by Rose Ellenby. Penguin Books, London and New York. $1.00. 32 pp. + 16 plates. 1945.

This compact little volume successfully maintains the standards which have characterized the other King Penguin books covering technical fields. The typography and general format of the book are excellent. The 16 pages of colored plates are in general accurate and effective, embellishing as well as supporting the compact text. The board covers, with conventional mushroom figures in a repeat pattern, are in colors sufficiently lurid and warning to give at once a subjective impression of poisonous qualities.

The general part of the text, in the brief space of 14 pages, covers the historical background of the recognition of poisonous mushrooms, gives the necessary definitions and derivations of terminology, and does a helpful service in pointing out the futility of the popular and superstitious criteria for distinguishing poisonous forms and emphasizing the need for the study of the essential features on which trustworthy recognition depends. Attractively written, this introductory general treatment is enlivened with the deftly whimsical and amusing touches for which the author is well-known.

The descriptive and more technical part of the text (16 pages), characterizes the important poisonous genera, emphasizes the several species of *Amanita* that are notably deadly, and briefly and effectively describes the poisonous species of lesser importance in 11 other genera, especially *Lepiota*, *Lactarius*, *Russula*, and *Entoloma*. Since practically all of the species discussed occur in this country as well as in Great Britain, the book will be of equal value here, although the illustration of *Amanita muscaria*, as shown in color plate 4, has the deeper red cap typical of the European form, less typical of those found in this country.

WILLIAM H. WESTON

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HENRICI'S MOLDS, YEASTS, AND ACTINOMYCETES: *A Handbook for Students of Bacteriology. Second Edition. By Charles E. Skinner, Chester W. Emmons, and Henry M. Tsuchiya. John Wiley & Sons, New York; Chapman & Hall, London.* $5.00. xiv + 409 pp.; ill. 1947.

This second edition will receive an enthusiastic welcome, not only from those already familiar with the valuable and useful first edition of 1930, but also from many additional readers who will learn how effectively this meets their needs and will appreciate the farsightedness of Henrici, who foresaw these needs many years ago. The present authors, Skinner, Emmons, and Tsuchiya, undertook the rewriting of the book largely out of regard for Dr. Henrici, whose failing health halted his own revision. Consequently, they have adhered closely to the spirit which motivated the original edition, namely, to present for the bacteriologist an effective discussion of molds, yeasts, and actinomycetes, together with a working knowledge of pertinent aspects of mycology which will greatly enhance his effectiveness in his own field. Toward this end the emphasis on the medical and industrial applications of mycology has been extended and intensified, and a sound working knowledge of the morphology of the fungi, their classification, cytology, genetics, life cycles, and development has been made available, so that the bacteriologist may more effectively understand such comparable aspects of his own field as the structure and development of bacteria and especially their variation and cycles of development.

The present volume has been notably extended, comprising 409 pages in contrast with the 296 of the first edition. Not only has the material been carefully reorganized, thoroughly revised, and extensively rewritten, but much that is recent, significant, and valuable has also been added. The second chapter, on Variations in the Lower Fungi, is a new one, and the only one prepared in full by Henrici himself; Chapter 14, on Antibiotic Substances, by Tsuchiya is new; and the revision and expansion by Emmons of the material dealing with Fungus Diseases of Man and Animals and with Infections Caused by Molds have contributed a large proportion of new subject matter to Chapters 6 and 7. The total number of chapters, therefore, is now 14 in contrast with the 11 of the first edition. In rewriting the book the three collaborators have cooperated effectively, each dealing with that area in which he was especially expert. In general, Skinner has carried out the revision of the chapters (I, III, IV, V, IX, and XII) concerned with general mycological matters; Emmons has covered the medical mycology (chaps. VI, VII, X, XIII); and Tsuchiya has handled nutrition, fermentation, antibiotic action, degradation, and other biologic activities (Chaps. VIII, XI, and XIV).

The total number of figures has been increased to 136, and while most of the 100 figures of the early edition have been retained, some that are more effective have been substituted and many new ones have been added. A number of valuable new tables has been added, especially in the chapters on the biological activities of molds. The lists of references to pertinent literature, usefully expanded and brought up to date, appear at the end of each chapter, except in the case of Chapter 7, in which instance the references dealing with the several infections caused by molds occur at the end of each section, being proportionately extensive after the full discussion of diseases such as coccidioidomycosis, the dermatophytoses, the blastomycoses and others, and less extensive after the briefer sections on diseases such as aspergillosis and mycetoma.

The chapter on variations in the lower fungi is a helpful addition that will contribute toward enlightening the bacteriologist on the vagaries of fungous behavior. The chapter on methods has been amplified to 30 pages, twice the length of the original, with numerous and recent literature references. The new material in this chapter includes additional information on special media and on the techniques for culturing, isolating, and examining the pathogenic fungi.

The discussion of the phycomycetous molds (chap. 4) has been condensed in revision, chiefly by the wise omission of the key to the species of *Mucor*, which occupied 4½ pages in the first edition; and some additional material has been included. The chapter on the molds of the Fungi Imperfecti and Ascomycetes (chap. 5) considers the Penicillia and Aspergilli in some detail, as befits the extensions since 1930 of our knowledge of these two important genera and, wisely omitting the key to the groups of species of *Aspergillus*, gives the readers a sound understanding of the requirements and taxonomic basis for identification and then refers him to the recent, complete, and authoritative *Manual of the Aspergilli* by Thom and Raper. This chapter also gives brief discussion of the chief characteristics of the more common molds which have especial interest and are likely to be encountered by the bacteriologist.

In conformity with the emphasis on the medical aspects of mycology, the four chapters concerned with the general aspects of the fungous diseases of man and animals, the infections caused by molds, the pathogenic yeast-like fungi, and the actinomycoses have been rewritten and expanded so that they add notably to the strength of the book. In this treatment of medical mycology considerable new material has been added, obsolete passages have been omitted, the nomenclature has been simplified and brought up to date, and the discussions of toxins and of the biochemical activities of the pathogens have been effectively expanded.

The chapters dealing with the biological activities of molds and yeasts and the industrial applications of these activities have been considerably expanded also. Fairly detailed accounts of the biochemical reactions involved are included, especially in the sections dealing with citric, gluconic, and other acid fermentations by molds and the alcoholic fermentation by yeasts. In addition, several new tables list the acids, pigments, and other metabolic products with their formulae, noting the organisms producing the products and, in some instances, including in the table the essential references to the sources of information.

The treatment of the structure and classification of the yeasts and yeast-like fungi, although covering in one chapter the material formerly given in two, has successfully achieved this condensation by a rewriting which effectively encompasses the notable advances in this field since the first edition was published. Similarly, the chapter on the actinomycetes presents an able treatment of the long established and the recently contributed material in this area.

The chapter on antibiotics, however, is somewhat disappointing, and is certainly not comparable to the rest of the book in effectiveness and adequacy of treatment. Also, although the illustrations as a whole are excellent, a few, such as Fig. 31 of *Pythium* and Fig. 70 of *Monascus*, are rather below the standards of the others.

The present book, even more than the first edition, fulfils Henrici's original purpose of filling the gap between the relatively ineffectual treatments of mycology in some bacteriological textbooks and the extensive technical mycological treatises with their detailed discussions of the fungi from the botanical, classificational, or plant pathological points of view. The three collaborating authors are to be congratulated on producing a book which not only attains the worthy objectives and maintains the high standards of Henrici, but also achieves a utility that will render it of great value to microbiologists, mycologists, and others in fields far removed from the bacteriologists to whose service it originally was dedicated.

William H. Weston

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Wild Flowers in the Rockies.

By George A. Hardy and Winifred V. Hardy; illustrated by Frank L. Beebe. H. R. Larson Publishing Company, Hamilton, Saskatoon, and Vancouver. $7.50. 125 pp.; ill. 1949.

In an artistic sense, this slender volume is in a class by itself. Its excuse for being is primarily to provide a medium of expression for the illustrator, Frank L. Beebe, and its proper place is a choice spot in the flower-lover's library. The 50 colored plates, each being made up of four species, are superbly reproduced on excellent paper, and their composition and accuracy of detail are ample evidence that Beebe is a competent naturalist as well as a first-rate artist. This is not a field botany book, however, despite its title. The accompanying descriptions are appreciative in tone rather than taxonomical; and the species depicted, while representative, include but a small number of the floral members of the Canadian Rockies. A grouping of the species by color, and secondarily by family, will enable one readily to track down any one of the 200 species included, and will thus satisfy those whose interest is confined to the more conspicuous flowers; but the availability of more inclusive field books and the rather prohibitive price of the volume will weigh against its general acceptance. On the other hand, the book is an excellent example of what can be done for a popular subject through close cooperation of illustrator and authors.

C. P. Swanson

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Shrubs of Michigan. *Bulletin Number 20, Second Edition.*

By Cecil Billington. Cranbrook Institute of Science, *Bloomfield Hills, Michigan.* $4.50. viii + 339 pp. + 3 plates; text ill. 1949.

It is rare that a book on taxonomy passes through a second edition in six years. A second printing usually suffices. The author, however, has felt, and with good reason, that since the nomenclature of the first edition conformed with that of Gray's *Manual* of 1908, a second edition was warranted in the light of changes which have been made since that time. The inclusion of many new shrubs, previously excluded or unknown in Michigan, also serves to give a more comprehensive treatment of the shrub flora of the state. To those readers who are not familiar with the first edition, this is a volume by an amateur botanist who writes for the amateur. The clarity of its descriptions and illustrations, however, would bring credit to a professional scientist, and the author and the Cranbrook Institute of Science are to be commended for an exceptionally well done and readable book.

C. P. SWANSON

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THE SHORTER BRITISH FLORA.
By C. T. Prime and R. J. Deacock; illustrated by A. Swaffer and A. I. Charlton. Methuen and Company, London. 12s. 6d. xl + 376 pp.; ill. 1948.

This is a small manual for the identification of about 720 species of the commoner British plants. The rarer species have been omitted. There is a brief introduction on how to use the book and a partially illustrated glossary. These are followed by a key to the families. The order of treatment is in general that of the Bentham and Hooker system. For each family there is a brief general description, a key to the common genera and species, and notes on the scientific and economic significance of some of its component species. Some of the more complex families, such as the Compositae, have supplementary illustrations to aid in their analysis. The book closes with indices to families and genera, and to English names. It is bound in cloth and is of handy size for carrying in the field.

H. M. RAUP

◆

DRAWINGS OF BRITISH PLANTS. *Being Illustrations of the Species of Flowering Plants Growing Naturally in the British Isles. Part I. Ranunculaceae. Part II. Berberidaceae, Nymphaeaceae, Papaveraceae, Fumariaceae.*
By Stella Ross-Craig; with a foreword by Sir Edward Salisbury. G. Bell and Sons, London. (I) 6s. (II) 4s. 6d. (paper). (I) 12 pp. + 44 plates; (II) 11 pp. + 22 plates. 1948.

The two volumes at hand consist entirely, except for the Foreword and brief introduction (duplicated in each), of superb drawings of British plants. The books are printed in octavo, and the drawings for each species cover a single page. The pages are printed on one side only, so that the drawings may easily be clipped.

H. M. RAUP

◆

TASCHENATLAS DER SCHWEIZER FLORA. *Mit Berücksichtigung der ausländischen Nachbarschaft.*
By Eduard Thommen. Verlag Birkhäuser, Basel. S. fr. 12.50. xvi + 294 pp.; ill. 1945.

This is a small handbook, bound in cloth, and suitable for easy field reference. With the exception of a brief introduction and list of author abbreviations, it consists almost entirely of small but clear line drawings of the flowering plants and ferns of Switzerland. The drawings include habit sketches and a wealth of detail showing the definitive characters of the species. The book closes with a partial list of the species, in which there are notes on range and occurrence. An index covers the genera, and the species in some of the larger genera. American botanists traveling in Switzerland should find the book useful for the determination of the native flora.

H. M. RAUP

◆

AN AUSTRALIAN WILD FLOWER BOOK. *Second Edition.*
By Charles Barrett. Geoffrey Cumberlege, Oxford University Press, Leighton House, Melbourne. $3.00. 205 pp. + 39 plates. 1947.

This small pocket volume contains descriptions of some of the more conspicuous Australian wild flowers. It is entirely non-technical, with no keys for identification, and consists of descriptive essays. Its arrangement is primarily geographical, as the following chapter heads indicate: Gems of the Bush, On the Heathlands, Western Wild Flowers, Tropical Beauty, Tasmania's Flora, etc. There is much lore concerning the history of the plants, their distribution, their appearance in cultivation, and the botanical exploration of Australia. The book is illustrated with handsome photographs in black and white or in color.

H. M. RAUP

◆

NOTES ON THE ACANTHACEAE OF JAVA. *Verhandelingen der Koninklijke Nederlandsche Akademie van Wetenschappen, Afd. Natuurkunde. Tweede Sectie, Deel XLV, Number 2.*
By C. E. B. Bremekamp. North-Holland Publishing Company, Amsterdam. F. 3.50 (paper). 78 pp. 1948.

This publication consists of critical notes on many genera and species in this complex family, with descriptions of new entities in both categories. The author presents some revisions in the organization of the family as it was expressed in his earlier publications.

H. M. Raup

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Flore Analytique et Synoptique de la Nouvelle-Caledonie Phanerogames. *Flore de la France d'Outre-Mer.*

By A. Guillaumin. Office de la Recherche Scientifique Coloniale, Paris. 1200 fr. (paper). 369 pp. 1948.

Guillaumin has for many years been a student of the flora of New Caledonia, and now presents in this volume analytical keys to the phanerogamic plants of that area. The key is arranged by families, and follows, in general, the system of Engler and Prantl. Under each family there is a brief description of the characters of the family as a whole, a key to its genera, and then keys to the species under each genus. The text is in French. An index at the end is limited to families and genera.

H. M. Raup

PLANT MORPHOLOGY

Practical Plant Anatomy. *Second Edition.*

By Adriance S. Foster. D. Van Nostrand Company, Inc., New York, Toronto, London. $3.00. xi + 228 pp. 1949.

The appearance of a second, completely revised and enlarged edition of *Practical Plant Anatomy* less than 10 years after its original publication readily attests the great popularity and wide acceptance of this exceedingly useful and highly informative book. The great advances in plant anatomy achieved in the interim have been carefully recorded in the largely rewritten and expanded chapters. These changes and the addition of a new exercise (no. 12) on laticiferous tubes, the laboratory directions of which were contributed by Katherine Esau, have increased the text by more than 70 pages. The physical make-up, too, has been greatly changed, for the former spiral binding has been replaced by a regular book binding.

Throughout the book the emphasis has been admittedly and correctly placed on the study of the *vegetative* organs of the higher plants, rather than on that of their reproductive organs or other special structures often treated in advanced courses in plant anatomy and morphology. Each chapter consists of a critical review of the pertinent data, interpretations and theories concerning the particular material covered, instructions for laboratory work, and an extensive bibliography containing both classical and recent references. As the laboratory instructions include ample suggestions for the use of a great variety of plants, frequently of economically important species, *Practical Plant Anatomy* can easily be used in conjunction with courses of widely differing content and scope.

Traditionally, progress in plant anatomy has resulted from investigations carried out along two main lines of research, the structural and the developmental (or physiological). However, in recent years, paleobotanical research has yielded such phenomenal results that some of these could profitably be included in the study of living plants. The application of epidermal and especially stomatal characters in the identification and classification of fossil (mainly Mesozoic) and living gymnosperms provides one of the most striking examples. In the light of these researches, the exercise on stomata would undoubtedly read very differently.

With all the changes made, the original purpose of the book has not been altered. Rather, the second edition is even more eloquent testimony to the author's broad research and teaching experiences.

Theodor Just

ECONOMIC BOTANY

Manual of Cultivated Plants *Most Commonly Grown in the Continental United States and Canada. Second Edition.*

By L. H. Bailey and the Staff of the Bailey Hortorium at Cornell University. The Macmillan Company, New York. $17.50. 1116 pp.; ill. 1949.

Ever since its appearance in 1923, Bailey's *Manual of Cultivated Plants* has been an indispensable reference work for all botanists, florists, and horticulturists. The appearance of a revised and up-to-date edition is most welcome. The new *Manual* is greatly enlarged, with 1523 genera and 5347 species now included (with incidental mention of many others), as against 1246 genera and 3665 species in the earlier work. Every effort has been made to bring the nomenclature into accord with the International Rules.

As in the first edition, the species treated are those commonly domesticated in the continental United States and Canada - the garden flowers, ornamental shrubs, greenhouse plants, vegetables, fruits, grains, grasses, and all other plants grown for food, ornament, usefulness or general interest, either in the open or under glass. Purely horticultural varieties are omitted.

In addition to the species commonly cultivated, three other categories are included: species which are no longer of commercial importance, but have been popular over the years and are still to be found in old gardens; new introductions not as yet fully established; and plants of importance in other parts of the world, which are as yet little known or appreciated in the United States.

The introductory material comprises a section devoted to the meaning of the specific names, a glossary of botanical terms, a list of the authorities for the binomials, and a key to the families of the Pteridophytes and Spermatophytes. The appearance and format of the book are excellent, and although much of the type is small, it is very easy to read. There are 195 text figures and a complete index. It is to be regretted that owing to present-day printing costs this valuable and essential work should have to be so high in price.

Albert F. Hill

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FRUIT SCIENCE. *Orchard and Small Fruit Management.*
By Norman Franklin Childers; edited by R. W. Gregory. J. B. Lippincott Company, Chicago, Philadelphia and New York. $5.00. x + 630 pp.; ill. 1949.

Although primarily intended for use as a college textbook, *Fruit Science* should also be valuable for fruit growers who wish to keep in touch with modern trends in pomological research. The method of treatment is quite different from that of most other works dealing with fruits. At least one-third of the book is devoted to the apple, which the author considers the most widely grown and the most important fruit. It is in connection with the apple that the underlying basic principles and practices of fruit growing are discussed. All phases of apple culture are included: regions, production, varieties, pruning, soil management, flower bud formation, pollination and fruit set, thinning, grafting and budding, frost injury, harvesting and packing, storing and marketing. Several chapters are devoted to other important deciduous fruits, such as the pear, quince, peach, nectarine, apricot, almond, plum, and cherry, in so far as their management differs from that of the apple. Small fruits - the grape, strawberry, raspberry, blackberry, blueberry, currant, gooseberry, and cranberry - are also considered.

Information is given with regard to the fruit industry, the establishment of orchards, control of insects and diseases, judging of contests and exhibitions, and the freezing preservation of fruits. Supplementary material includes a selected list of collateral readings for each chapter, an enumeration of the Agricultural Experiment Stations and Colleges in the United States and Canada, scientific journals in the field of pomology, a list of scientific names, and an index.

Albert F. Hill

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BANANAS: *Chemistry, Physiology, Technology. Economic Crops, Volume I.*
By Harry W. von Loesecke. Interscience Publishers, New York and London. $4.50. xii + 189 pp. + 2 plates; text ill. 1949.

With *Bananas*, Interscience Publishers present the first volume of a projected series of monographs dealing with the chemistry, physiology, and technology of food and food products. Quite aside from the manifest value of this book to those interested in food technology, there is compiled here a worthy store of information relating to the structure and development, chemical changes during ripening, respiration, volatile constituents, enzymes, and insect and fungus diseases of the banana. There are also chapters which deal with commercial storage and ripening methods, transportation, banana products, and nutritive values in health and disease. The account begins with the history and origin of the fruit and concludes with statistics describing world production and trade.

V. G. Dethier

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VEGETABLE SCIENCE.
By H. D. Brown and Chester S. Hutchison; edited by R. W. Gregory. J. B. Lippincott Company, Chicago, Philadelphia and New York. $5.00. x + 452 pp.; ill. 1949.

This book is designed both as a manual for farmers who grow vegetables commercially and as a textbook for students. Fundamental modern practices are presented in a clear and concise manner. Economical procedures are stressed; and a brief history and description of each vegetable are given for those interested in the more academic phases of the subject. A series of review questions and a short bibliography are appended to each chapter. An index is also available.

Albert F. Hill

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ORCHIDS ARE EASY TO GROW.
By Harry B. Logan and Lloyd C. Cosper; drawings by Lynette Arouni. Ziff-Davis Publishing Company, Chicago and New York. $6.00. viii + 312 pp. + 20 plates; text ill. 1949.

The rapidly expanding role of orchids in horticulture created a demand for a manual of orchid culture which would be comprehensive in scope, simple in treatment, and factually sound, yet written in non-technical language. The authors have made a sincere and quite successful effort to meet this demand, keeping in mind the ever-increasing number of amateurs who have succumbed to the allurements of this royal family of plants.

The division of the book into two parts follows rather standardized practice in works of this kind. Part One, The Mechanics of Orchid Culture, treats orchids in general, discussing their geographical distribution, morphology, culture, and allied subjects of greenhouses, composts, pests, and diseases. A chapter is devoted to the outdoor culture of orchids and another to the growing of orchids in the home, with or without a growing case. Miniature greenhouses and Wardian cases are dealt with in another chapter.

Part Two, Orchids You May Grow, is in part a series of chapters, each devoted to a single genus of horticulturally popular orchids. The treatment is novel, being in narrative form rather than in the more customary descriptive paragraphs. In addition, the chapter on orchids for special purposes and another on cultural and descriptive tables are highly specific in content and should be of especial value to the connoisseur as well as the novice. An extensive bibliography and an adequate index conclude the work. Though the book contains a number of errors and some of the statements can be considered at least controversial, it is an excellent contribution to its field and will be a standard for comparison for any future work.

GORDON W. DILLON

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GLADIOLI. *Second Edition. The Home Garden Books.*
By A. J. Macself. Eyre & Spottiswoode, London. 6s. x + 87 pp. + 1 plate; text ill. 1948.

For several years there has been available a series of small handbooks, The Home Garden Books, which afford the amateur gardener practical and helpful information on a variety of subjects. One of these handbooks, devoted to Gladioli, has been completely revised to include new and up-to-date information, especially with regard to those modern developments which have enhanced the importance and serviceability of the plant. All phases of gladiolus cultivation are covered: early-flowering types; general culture; growing for exhibition, and for stock; cutting, packing, and staging; the adaptability of cut flowers; commercial culture, and growing from seed; pot culture; and diseases. A brief history of the plant and a list of species are included. The book has a short index and is illustrated with a colored frontispiece and 22 line drawings.

ALBERT F. HILL

◆

GLADIOLI AND DAHLIAS.
By Chas. W. J. Unwin. W. H. & L. Collingridge, London. 6s. 125 pp.; ill. 1949.

This little book is a highly authoritative guide to the successful cultivation of these two popular garden flowers. The author, a well known breeder, grower, and exhibitor, presents his facts in a very readable manner. The chapters devoted to Gladioli cover such topics as types and races, utilization for such varied purposes as shows, gardens, or the home, cultural notes for exhibitors, routine culture, raising young stock, and hybridization. Dahlias are discussed under such headings as varieties, cultural requirements, propagation, and hybridization. The author concludes with a plea for a return to the compost heap, rather than too great a dependence on chemical fertilizers.

ALBERT F. HILL

◆

DELPHINIUMS. *Their History and Cultivation. Second Edition. The Home Garden Books.*
By George A. R. Phillips. Eyre & Spottiswoode, London. 6s. x + 114 pp. + 5 plates; text ill. 1949.

A second handbook of the Home Garden series—devoted to Delphiniums—has also been completely revised and rewritten. The most recent cultural practices are described, and the newer as well as standard varieties are discussed. The scope of this little manual is such that it should be valuable to amateurs and commercial growers alike.

ALBERT F. HILL

◆

SHRUBS FOR THE MILDER COUNTIES.
By W. Arnold-Forster; foreword by The Right Hon. Lord Aberconway; with a chapter on Magnolias by G. H. Johnstone. Country Life, London; Charles Scribner's Sons, New York. $10.00. xvi + 367 pp. + 41 plates. 1948.

Although written for an English public, American gardeners and landscape architects will find much of value in this work. Unlike most books dealing with shrubs, the present volume emphasizes the more delicate species which can be grown in milder areas, as well as the hardier ones which have a wider range of usefulness.

One chapter is devoted to plants which are capable of withstanding sea winds; another is concerned with roadside, estate, and town plantings. The largest portion of the work—111 pages—gives a general planting list with a wealth of information concerning each species and derived from the author's lifetime experience as a practical gardener.

Special sections are devoted to acacias, camellias, *Ceanothus, Eucalyptus, Metrosideros, Nothofagus, Olearias, Prunus, Pyrus, and Sorbus,* Rhododendrons and Magnolias, the latter chapter by G. H. Johnstone, the eminent authority on this group. A final chapter is concerned with shrubs which are still in the experimental stage. There is an adequate index.

ALBERT F. HILL

◆

THE STORY OF TOBACCO IN AMERICA.
By Joseph C. Robert. Alfred A. Knopf, New York. $5.00. xiv + 320 pp. + 4 plates; text ill. 1949.

Some of our economic plants have played such an important role in the development of the United States that an account of their history is in great part a history of the nation itself. Such is the case with tobacco. The present volume traces the history of tobacco in America. It not only outlines the various phases of the industry itself, but also discusses the vital effect of tobacco on the political, social, and economic life of the country from earliest colonial times to the present.

The author, a professor of history at Duke University, in very readable words brings home his thesis that without some knowledge of tobacco it is impossible to understand fully such important events as the founding of the Chesapeake colonies, the development of slavery, the advent of the Revolution, or the early diplomacy of the Nation. States' rights, the growth of Big Business, and the agrarian aspects of the New Deal have all been affected by tobacco. Even more pronounced has been the impact of tobacco on the economic and social life of the country, with the changing customs in its use from snuffing and dipping through the rise of the cigar to the present amazing dominance of the cigarette.

The book is arranged in chronological order by periods. A list of the chapter headings and subtitles will give some idea of the scope of the work and the interesting subject matter:

1492–1776. The Discovery of "That Bewitching Vegetable"; First American Aristocrats—Sweet Scented and Oronoko; Great Planters of the Tidewater; Tobacco Merchants of Britain; The Parson's Cause.

1776–1860. New Fields and Changing Markets—The Revolution and Diplomacy; Frontier Planters and the "Spanish Intrigue"; A Revision of Plantation Arts; Rollers, Boatmen and Auctioneers. The Chewing Tobacco Era—Industrialists in an Agrarian Society; Slaves in the Tobacco Factories; Trade Names and Wooden Indians; Reformers and the Tobacco Habit.

1860–1911. The New South and Big Business—In the Land of Johnny Reb; The Birth of the Golden Calf; The Old Guard and Newcomers; W. Duke & Sons; The Tobacco Empire. The Age of Conflict—Night Riders *versus* Hill Billies; "Blood Money" and Trust Busters; The Little White Slaver; Drummers and Cigar Makers; Bright Leaf and Burley.

1911–1941. Farmer and Leaf Market—The Warehouse Scene; Troubled Waters of the Tobacco Pools; Tobacco and the New Deal; The Modern Tobacco Farmer; Marshall's "Really Good Five-cent Cigar." The Cigarette Age—Camels Lead the Way; The All-American Cigarette; And Still the Coffin Nail; The Battle of Lexington, Kentucky.

1941–1948. The End of Tobacco Road.

A very complete bibliography and index add much to the value of the book.

ALBERT F. HILL

◆

DRUGS FROM PLANTS. *Sigma Introduction to Science, 10.*

By Trevor Illtyd Williams. Sigma Books, London. 6s. 119 pp. + 12 plates. 1947.

The author of *Drugs from Plants* believes it important for cultural and economic reasons to furnish the general reader with popular interpretations of science. In this book he has most effectively presented accurate information regarding vegetable drugs in an entertaining and readable manner. His subject is well chosen, for few other fields combine such a fascinating and well documented period of empiricism and superstition with a later one of precise scientific method.

In an introductory chapter, Williams gives a brief history of the medicinal uses of plants from the time of Egypt, Babylon, and Assyria to the days of the Herbalists and the Doctrine of Signatures. He then shows how scientific methods of investigation have made it possible to distinguish the few really useful plants from the great mass of remedies which had their origin in ignorance and superstition, and to assess their true value. A chapter on the classification of drugs, chiefly from the chemical standpoint, is followed by a detailed account of seven important drugs—quinine, hashish, digitalis, penicillin, ergot, opium, and cocaine. Another chapter is devoted to miscellaneous drugs, including belladonna, hyoscyamus, mandrake, aconite, poison hemlock, hellabore, strychnine, caffein, colchicum, ephedrine, calabar beans, chaulmoogra, and curare.

The final chapter, What of the Future?, is of special interest. The author feels that continued research will lead to the discovery of additional valuable drugs and also make possible important contributions in the fields of botany and chemistry. As possible topics for investigation the author suggests the following: antibacterial properties; the development of synthetic drugs following the study of natural ones; the mode of action of drugs and the relationship between their chemical structure and physiological action; the manner in which the drugs are formed and their function in the plant's economy; the search for new and high-yielding strains, or their development through breeding; and the use of chemical methods in botanical classification.

ALBERT F. HILL

◆

GREEN GLORY. *The Forests of the World.*

By Richard St. Barbe Baker, with a foreword by Howard Spring. A. A. Wyn, Inc., New York. $3.50. 253 pp.; ill. 1949.

This is a story of the forests of the world: their extent, character, and variety; their role in maintaining a balance in nature; their destruction, management, and replacement; and, lastly, but most important, the consequences of their mismanagement upon the character of the countryside and upon the economy of nations. It is a story which has been told many times before, but rarely so effectively. With the possible exception of South America, no region of the world has been spared the destruction of its forests which has so closely followed the colonization of the land. Only a handful of nations—Sweden, Finland, Russia, Yugoslavia—have recovered to a point where the harvesting of trees is matched by the rate of replacement. The consequences have been inevitable and disastrous. The floods of the Yellow River which have depleted great areas of topsoil in China; the steady advance of the Sahara and Arabian deserts, which but short centuries ago were clothed in forests; and in our own country, the Dust Bowl of the 1930's, the passing of the tremendous white pine forests of the north, and the perilous lowering of the water table in the southwest are but a few examples of the effects of widespread deforestation. Roosevelt's Civilian Conservation Corps, formed in the depression days to combat unemployment, can trace its origin to forest depletion and the need for conservation practices.

This book, however, is more than an eloquent plea for conservation. It is an urgent warning that the well-being of a nation—and the United States is no exception—is intimately bound up in innumerable ways with its forest resources, and that the destruction of these without their replacement is national suicide. To be sure, steps have been taken to replace our dwindling reserves, but the United States, like other nations, long ago passed the point of being self-sufficient in this respect. The author knows his subject, and he speaks with a conviction arising out of this sure knowledge. One can only wish that his proposal to the United Nations to turn the armies of the world into foresters would be considered seriously by all nations. If a criticism of the book is to be made, it is that the style of writing is too flowery and sentimental. Chapters 1, 3, and 5 could just as well have been omitted as superfluous. These shortcomings, however, are compensated by a number of superb photographs, and by the thoroughly interesting subject matter.

C. P. SWANSON

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FOREST PATHOLOGY. *Second Edition. The American Forestry Series.*

By John Shaw Boyce. McGraw-Hill Book Company, New York, Toronto and London. $6.00. xii + 550 pp.; ill. 1948.

The present revision brings up to date the topics discussed in the 1938 edition of Boyce's well-known book. The specialized field of forest pathology encompasses portions of many and varied botanical sciences. Consequently, the compilation of the data on this subject in a book that serves equally well as a textbook for the student, a source of enlightenment for the conservationist, and a reference for the specialist, is to be highly commended.

The subject is most logically treated, from an excellent introduction through diseases of the seedling and the mature tree, the deterioration of dead timber and of forest products, and, finally the principles of disease control. Supplementing the chronological treatment, the diseases are grouped according to the part of the host attacked. This approach, instead of that by the causal agent, enhances the usefulness of the book for those who are not trained pathologists. The new forest diseases are discussed, and there is a change in emphasis on some of the old. However, the author does not contend that the amount of space allotted to a specific disease is consistent with its economic importance. The book is based on published literature, so that the amount of such information available has greatly influenced the length of discussion of a given disease. Comprehensive lists of references are given at the end of each chapter. Like its predecessor, this book will be invaluable to all those interested in forest pathology.

BERCH W. HENRY

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AUSTRALIAN JOURNAL OF AGRICULTURAL RESEARCH. *Volume I, Number 1. January 1950.*

Editorial Advisory Committee: Chairman and Editor, Dr. N. S. Noble. Members: Dr. H. E. Albiston, Dr. L. B. Bull, Dr. H. C. Forster, Associate Professor G. W. Leeper, Professor S. M. Wadham. Commonwealth Scientific and Industrial Research Organization in collaboration with the Australian Institute of Agricultural Science and the Australian Veterinary Association. 30s. per year (four issues per year). No. 1: Pp. 1-102; ill.; 1 plate.

This journal has been founded to publish original investigations into the physical, chemical, and biological aspects of soils, plants, and animals. It will presumably supersede, at least to a considerable degree, the series of Bulletins published by the C. S. I. R. on these subjects. Each article is preceded by a summary. Contents of the first issue: Some effects of leaf-roll virus on the development and growth of the potato plant (J. G. Bald & E. M. Hutton); Transmission of potato virus diseases. VI. The distribution of the aphid vectors on sampled leaves and shoots (J. G. Bald, D. O. Norris, & G. A. Helson); Seedling blight. I. Seed colour and soil in relation to pre-emergence blight of William Massey peas (H. R. Angell); Pot culture studies of the copper and molybdenum content of certain pasture plants (C. W. E. Moore); Differential effects of certain phenoxyacetic acid compounds and phenylcarbamates on plant species. I. Effect of applications to the soil prior to emergence (R. M. Moore); On the abundance of the Australian plague locust, *Chortoicetes terminifera* Walker, in relation to the presence of trees (L. R. Clark); Mating and lambing in an experimental flock of merino sheep (J. F. Kennedy & R. A. Bettenay); A technique for the collection of nematodes from the alimentary tract of sheep (F. J. Hamilton); Methods for egg counts and larval cultures for Strongyles infesting the gastro-intestinal tract of cattle (F. H. S. Roberts & P. J. O'Sullivan).

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THE NON-PARASITIC DISORDERS OF APPLE FRUITS IN AUSTRALIA. *Commonwealth of Australia, Council* *for Scientific and Industrial Research, Bulletin No. 238.*

By W. M. Carne. Council for Scientific and Industrial Research, Melbourne, Australia. Free upon request (paper). 83 pp.; 24 plates. 1948.

GENERAL AND SYSTEMATIC ZOOLOGY

AN INTRODUCTION TO ANIMAL BIOLOGY. *Third Edition.*

By John B. Parker and John J. Clarke. The C. V. Mosby Company, St. Louis. $4.00. 554 pp.; ill. 1949.

Little change marks this new edition of a college zoology textbook prepared especially for Roman Catholic schools. The chapter on Vitamins and Hormones has been brought up to date, and the major Rh blood types are given space. Non-Catholic biologists who wish to see how the subject of Organic Evolution is treated by Roman Catholics will find this book a good one to consult.

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LABORATORY DIRECTIONS FOR GENERAL ZOOLOGY.

By Department of Zoology Staff, The State University of Iowa. The Williams Surgical Supply Company, Iowa City; Burgess Publishing Company, Minneapolis. 85 cents (paper). vi + 36 pp. 1945.

A LABORATORY MANUAL FOR ELEMENTARY ZOOLOGY. *Revised Edition.*

By W. Byers Unger and C. E. Moritz. Ginn and Company, Boston, New York, Chicago, Atlanta, Dallas, Columbus, San Francisco, Toronto and London. $2.25. vi + 184 pp. 1949.

This reviewer will give up the attempt to render any further opinions on laboratory manuals for general zoology. Each one that turns up is different, not only in philosophy of approach to the subject matter, but also in choice of laboratory animals, amount of dissection and observations required, use of terminology, etc. Any particular instructor needs only to decide how he wants to teach the course and then scout around until he finds a suitable manual. Even with such a wealth of material available, he probably won't be satisfied until he devises one of his own. Since the manual is so intimately tied up with the manner of presenting the subject, any criticism of the former is merely a reflection on the latter.

Under present discussion we have the Dartmouth College and State University of Iowa manuals. The former is cloth bound, the latter paper bound with spiral rings. Both are printed only on one side of the page, the former on the left, the latter on the right and in two columns. The Dartmouth manual starts with a page on terminology and proceeds with the workings of the microscope. The Iowa Manual starts with general information on drawings, supplies, locker assignments, and what would appear to indicate an anticipated limited distribution, a paragraph to the effect that lost articles are placed in Room 105. The first study commences with the frog and describes external features, through muscles and sensory organs. This is followed by the study of the microscope, then cells and tissues, mitosis, and maturation through cleavage. Then follow studies on successive phyla from the Protozoa to *Drosophila.* The latter initiates the study on heredity. The final study, a survey of selected phyla, is apparently adaptable for Iowa courses, since it is condensed to three paragraphs devoted to demonstration material.

The Dartmouth Manual continues its microscope study with a survey of the phyla, culminating with the frog. A study of vertebrate systems follows, using the frog as type, although dog skeletons, pig kidneys, and sheep brains are included. Embryology, histology, cytology (i.e., gametogenesis in frog and mouse), and meiosis and mitosis in *Ascaris* complete the work. Broadly speaking, the Dartmouth manual does not go into quite so much detail per animal as the other, but includes more different kinds. The sequence is obviously the most differentiating characteristic and as was said, the value of each method cannot be honestly evaluated without knowing the nature of the complete course itself.

HENRI C. SEIBERT

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THE SPONGES OF WOODS HOLE AND ADJACENT WATERS. *Bulletin of the Museum of Comparative Zoölogy at Harvard College. Volume 103, Number 1.*

By M. W. de Laubenfels. Museum of Comparative Zoölogy, Cambridge. $1.00 (paper). 56 pp. + 3 plates. 1949.

"First, an account, with detailed descriptions, illustrations, and a key to the known and highly probable species of Woods Hole itself. Second, an annotated review of the literature references to sponge occurrences from Newfoundland at the north to the Carolinas at the south."

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THE PYCNOGONIDA OF THE WESTERN NORTH ATLANTIC AND THE CARIBBEAN. *Proceedings of the United States National Museum, Volume 97, Number 3216.*

By Joel W. Hedgpeth. Smithsonian Institution, Washington, D. C. Paper. Pp. 157–342 + 1 map; text ill. 1948.

REPORT ON THE PYCNOGONIDA COLLECTED BY THE ALBATROSS IN JAPANESE WATERS IN 1900 AND 1906. *Proceedings of the United States National Museum, Volume 98, Number 3231.*

By Joel W. Hedgpeth. Smithsonian Institution, Washington, D. C. Paper. Pp. 233–321 + 1 map; text ill. 1949.

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The First Book of Bugs.

By Margaret Williamson. Franklin Watts, New York. $1.50. 45 pp.; ill. 1949.

This book describes various activities of insects that should be readily observed by the children for whom it is intended. Included are crickets and their relatives, ants, moths and butterflies, bees and wasps, and other insects. In addition, spiders are included, but as the author specifically states, her use of the term bug is to be taken in the popular rather than in the scientific sense.

Although the style is quite anthropomorphic, it must be remembered that this is a book for children who, if interested, can learn the facts of life later. The material is well presented and is supplemented by many attractive colored illustrations.

John Cushing

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What Butterfly Is It?

By Anna Pistorius. Wilcox & Follett Company, Chicago, New York and Toronto. $1.25. 25 pp.; ill. 1949.

The title of this book reveals its purpose very well. It consists of a series of colored pictures of 26 common butterflies that are very well executed and enable the beginner to make rapid and easy identifications. Accompanying each picture is a paragraph on some of the characteristics of the butterfly figured. These individual comments on life histories are preceded by a general account, a page in length, telling how a butterfly grows.

Although primarily for older children, this book should also be of interest to adults who would like to make a casual acquaintance with butterflies.

John Cushing

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The Nearctic Members of the Genus Lycaeides Hübner (Lycaenidae, Lepidoptera). *Bulletin of the Museum of Comparative Zoölogy at Harvard College. Volume 101, Number 4.*

By V. Nabokov. Museum of Comparative Zoölogy at Harvard College, Cambridge. $1.60 (paper). ii + Pp. 479–541 + 9 plates. 1949.

A study of the subspecific forms of *L. argyrognomon* and *L. melissa.* Ten subspecies are assigned to the former species, two being new, and five are assigned to the latter species, one being new.

Coleoptera or Beetles East of the Great Plains.

By J. Gordon Edwards. Published by the author, 392 Prairie Avenue, Wilmington, Ohio. $3.50. viii + 181 pp.; ill. 1949.

Undoubtedly there are still great gaps in our knowledge of the classification and biology of the insects. This is chiefly due to the enormous number of species in existence. One great drawback is that for many groups there is no easy way by which a species can be identified. Probably many more persons would become interested in this subject were it not for such stumbling blocks encountered at the very beginning of the study of insects. This is particularly serious for the beetles, which form the largest order of insects, and of which about 24,000 species are known to exist in the United States alone.

It is practically impossible for a beginner to identify a beetle which he might encounter in a fauna relatively as well known as that of the eastern United States; in many cases it is even very difficult for a person with considerable experience. There has never been a manual covering this area. The closest approach has been Blatchley's well known *Coleoptera of Indiana* which, besides being restricted to one state, has now a somewhat antiquated approach and has, moreover, been out of print for many years. The difficulties exist even when one is satisfied to track the beetle down only to family or genus. Practically all the keys that have been published make use of characters which are difficult to observe for the uninitiated worker. Furthermore, in nearly every key with which the reviewer has come in contact there are demonstrable inconsistencies and errors.

This book by Edwards is a very welcome step in the right direction. It consists of an extensive key to the beetle families (sometimes to smaller units), a description of the chief characteristics of each family, brief descriptions of the principal species, including their larvae, biological remarks, and finally a list of the principal publications dealing in detail with the species of that family. The author breaks with a few traditions, which is fortunate in some instances, less fortunate in others. The family key is not just a modified copy of previous keys but is a new approach, using wherever possible simple characters that can be recognized by the beginner. As the sole purpose of a key is a quick and unambiguous identification of a specimen, this is highly commendable and needs no apology. On the other hand, if the fundamental characters which define the family are avoided, there is danger of a slip now and then, and this the author has not entirely avoided. It would, for instance, be impossible to track down the common Mexican bean beetle in the family key, or, if one would guess its family correctly, to identify it from the description under the family Coccinellidae, as the author has overlooked the fact that *Epilachna* is one of the hairy genera of lady beetles. There are similar flaws in other groups.

The literature references are very valuable. Anyone who actually wants to identify a beetle as to species will need to have recourse to the original descriptions or to more recent revisions of certain groups. It is somewhat puzzling why certain publications were included, but others omitted. Blatchley's *Coleoptera of Indiana* is mentioned 99 times, whereas such papers as, e.g., Dobzhansky's monograph on the genus *Coccinella*, Leng's revision of *Brachyacantha*, and Dawson's papers on *Serica*, without which any attempt to classify beetles of these genera would be futile, have been omitted. The book is illustrated with many drawings which make it much easier and more definite to recognize the characters important for the identification than would any number of descriptive words.

This book can be highly recommended to the beginner in the study of beetles, if he realizes that it is not infallible. It is to be hoped that the author will soon be able to bring out a second edition from which the shortcomings could be easily eliminated.

G. H. DIEKE

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COLEOPTERA: CLERIDAE. *Contributions toward a Knowledge of the Insect Fauna of Lower California. No. 12. Proceedings of the California Academy of Sciences. Fourth Series. Vol. XXIV, pp. 485–519. January 26, 1950.*

By William F. Barr. The California Academy of Sciences, San Francisco. 65 cents (paper). 34 pp. 1950.

Forty-one species, six of which are new, and two subspecies are treated in this paper. Ten of the previously known species and subspecies are recorded from Lower California for the first time.

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OBSERVATIONS ON BATRISODES (COLEOPTERA: PSELAPHIDAE), WITH PARTICULAR REFERENCE TO THE AMERICAN SPECIES EAST OF THE ROCKY MOUNTAINS. *Bulletin of the Chicago Academy of Sciences, Volume 8, Number 3.*

By Orlando Park. Chicago Academy of Sciences, Chicago. Paper. Pp. 45–132 + 11 plates. 1947.

CHECKLIST OF THE GENUS BATRISODES (COLEOPTERA: PSELAPHIDAE). *Bulletin of the Chicago Academy of Sciences, Volume 8, Number 4.*

By Orlando Park. Chicago Academy of Sciences, Chicago. Paper. Pp. 137–169. 1948.

THE RELATIONSHIPS AND ZOOGEOGRAPHY OF THE GENUS THALEROPHIS OLIVER. *Bulletin of the American Museum of Natural History. Volume 92: Article 4.*

By James A. Oliver. American Museum of Natural History, New York. $1.75 (paper). Pp. 157–280 + 4 plates; text ill. 1948.

It is almost traditional for University of Michigan herpetologists to compile excellent generic monographs. Ruthven's revision of the garter snakes in 1908 was an impressive pioneering work. Blanchard's review of the king snakes in 1921, Ortenburger's of the racers in 1928, and Gloyd's of the rattlesnakes in 1940 are a few additional examples of this outstanding series. The present contribution continues, and in some ways extends, the high standards that have come to be expected by systematic zoologists.

Thalerophis is a genus of green, semi-arboreal to arboreal, neotropical snakes in which Oliver distinguishes six species, one of which has 2 races and another, 12 races. The genus is most closely related to other neotropical genera (*Drymobius* and *Dryadophis*) and not to superficially similar tree-snakes of the Old World, as has previously been thought. The genus probably originated in lower Central America, from which locality it has spread, northward and southward, into virtually all of the humid, warm, lowland, forest areas of the western hemisphere.

The paper is organized into a number of sections which are, essentially, as follows: taxonomy, character analysis and clines (in which is included a good deal of general ophidian biology), individual species accounts, and general phylogenetic considerations. There is a bibliography.

The disentanglement of a rather complicated nomenclatorial snarl seems to have been capably handled. Oliver has joined with a small group of rebels in not using parentheses (as required by the International Rules of Zoological Nomenclature), presumably because he has felt that they have not been used properly by many zoologists and, therefore, to that extent have lost their meaning. His general systematic philosophy is conservative, if conservatism is interpreted to mean placing forms in the least inclusive applicable taxonomic category; he writes: "... it appears to me to be more logical in the absence of definite proof of intergradation or reproductive isolation between closely related allopatric or geographically vicarious forms to consider them as subspecies rather than species." (p. 166).

The material on morphological characters is treated in a refreshingly novel fashion and is especially well handled. There are many attempts at analyses of quantitative data which seem to be done with concepts of modern genetics and population biology rather than with a consideration of specimens as a chance collection of natural artifacts. Unfortunately, the analyses are largely qualitative or only partly quantitative. There is much information in the raw data that has not been extracted, and the raw data are not available in the paper. This particular section will be of interest not only to specialists concerned with the genus but also to a large number of general systematic zoologists, regardless of the group with which they are primarily concerned.

The accounts of the individual species comprise a monument to the author's effort. To an unusual degree, most of the information presented is new and relatively little is derived from compilation. For example, of the 18 recognized forms, one-third have been described by Oliver during the course of this study. These accounts are illustrated with spot distribution maps and with excellent and striking drawings of heads, scale patterns, and hemipenes. Each species account contains an outline synonymy (a single citation for the first use of each name applied to a form), a statement about the type locality and range, and a fairly detailed description of scutellation and color. The account continues with a discussion of variation and various pertinent remarks. Each account is concluded with a list of the specimens that were examined, giving locality data and museum number. All in all, about 900 specimens were studied; for one race Oliver had available as many as 194 specimens, yet for another, only 5. There are keys to the forms. An additional welcome feature would have been a table to summarize the ranges of the more important systematic characters for each of the forms.

Oliver has spared no effort in gathering information about these snakes, even if it was not particularly germane to the present paper. He has an interesting section on food habits, in which it is rather clearly pointed out that although the snakes are diurnal, the organisms that make up their diet (largely hylid frogs) are nocturnal or crepuscular in habit. He suggests: "There may be possible advantages to a predator in locating its prey at a time when the latter is in a quiescent state and from which it emerges under a relative disadvantage in sensory efficiency as compared with that of the active predator."

The format is very pleasing and the editorial work is of the same high standard as the content; I was able to locate only two minor typographical errors.

ARNOLD B. GROBMAN

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A REVISION OF THE BIRD FAMILY DICRURIDAE. *Bulletin of the American Museum of Natural History. Volume 93: Article 4.*

By Charles Vaurie. American Museum of Natural History, New York. $1.75 (paper). Pp. 199–342; ill. 1949.

Not since 1877 has the family Dicruridae, the drongos, been revised, with the result that the taxonomy of this group has become hopelessly out of date. The present revision is based on an examination of nearly 3600 specimens, including all but two of the accepted forms. The 14 or so genera into which the family was originally divided is herein reduced to two, one being monotypic. These are *Chaetorhynchus*, whose tail has 12 rectrices, and *Dicrurus* with 10 rectrices. Twenty species are recognized in the latter genus, some of which contain many geographical subspecies. This lumping results from the fact that characters formerly considered as being of generic distinction show considerable overlap when large series are compared, and the same situation exists with what were formerly considered specific differences. The probable evolution of various characters such as tail, crest, and eye color are discussed as well as traced geographically on maps. The synonymy is complete, and each species and subspecies is described as to plumage, size, and range. In spite of this rather exhaustive treatment, only one new form is described, *Dicrurus hottentotus renschi* from Sumbawa, and only one new name proposed, *D. paradiseus ceylonicus*. A large table gives comparative measurements of significant parts of all forms. Professional ornithologists with taxonomic inclinations will welcome this important contribution, which will become a standard reference for this family of birds.

HENRI C. SEIBERT

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STUDIES IN THE PERAMELIDAE (MARSUPIALIA). *Results of the Archbold Expeditions. Number 60. Bulletin of the American Museum of Natural History. Volume 92: Article 6.*

By G. H. H. Tate. American Museum of Natural History, New York. 50 cents (paper). Pp. 313–346; ill. 1948.

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ECONOMIC ZOOLOGY

A TEXTBOOK OF AGRICULTURAL ENTOMOLOGY. *Second Edition.*

By Kenneth M. Smith. Cambridge University Press, Cambridge and New York. 18s. xiv + 289 pp.; ill. 1948.

After 17 years this edition again brings into print a small, concise manual of specific farm and livestock pests of importance in Great Britain. It is hardly a textbook, as the term is used in the United States, but a rather technical reference for the trained entomologist. Its small size is made possible by the exclusion of fruit insects and by inclusion of very little in the way of general discussion, which omits even insecticides and equipment.

The first three chapters, respectively, consider the organization of agricultural entomology (agencies) in England and Wales; methods of insect control through cultural, biological, and legislative means; and the effect of weather conditions on insect outbreaks.

The next ten chapters deal with the various insect pests under their taxonomic positions in the several orders, with but short diagnostic statements for the order, suborder, or family. No keys or elementary morphology are presented, the reader being referred for these to Imms' *General Textbook of Entomology.* Each species is described in full detail in its various stages, but the terms used are those of the taxonomist. Brief notes are given regarding control, but equipment is taken for granted in most instances. Rather thorough treatment of the life history and the natural enemies of each pest is one of the commendable points of the book. The fourteenth and final chapter discusses the insects and virus diseases of crops in a detailed fashion under each crop. In spite of the vast literature on plant viruses and their transmission, the bibliography of this chapter contains but four cited references, of which two are papers by the author.

There are two excellent appendices, the first of which tabulates by crops the symptoms characteristic of insect attack, while the second tabulates by botanical names the common forms of weeds which serve as alternate hosts for many insect pests. A separate index of parasites and predators follows the appendices, and is arranged alphabetically by scientific name under the insect orders, with the page reference cited for each host.

Since the first edition of this book appeared in 1931, it is only reasonable to expect considerable revision in the present volume, but unfortunately this second edition represents little more than a reprinting. Perfunctory additions have been made in a few instances, with none of the book having been rewritten except the final chapter on viruses and a very few sections on life history or control. As a result, the earlier pagination and illustrations have been successfully retained up to the last chapter; only one new reference (p. 187: 23A) could be found among the several appended bibliographies for the first 13 chapters; and more surprising, the first paragraph of the introduction remains as written in the first edition, leaving the reader to ponder statements which are curiously out of place.

ROBERT MATHESON

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THE COMMERCIAL FISH CATCH OF CALIFORNIA FOR THE YEAR 1947 WITH AN HISTORICAL REVIEW 1916–1917. *State of California, Department of Natural Resources, Fish Bulletin Number 74.*

By the Staff of the Bureau of Marine Fisheries. Division of Fish and Game, Bureau of Marine Fisheries, State of California Department of Natural Resources, Terminal Island, California. Paper. 268 pp.; ill. 1949.

This 30-year review, covering the period of California's rise to a major fisheries state, includes, in addition to the summaries of the catches of important commercial fishes, information on shellfish, octopus, and whales, and to a limited extent, data on sport fishing and bait species. Seaweed landings are omitted.

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FISHING THE ATLANTIC.

By S. Kip Farrington, Jr. Coward-McCann, Inc., New York. $6.75. xxii + 312 pp.; ill. 1949.

Farrington covers the Atlantic, from Nova Scotia to Venezuela, the Bahamas, and selected spots on the other side. His idea of fishing is the chartered boat, elbow-bending approach, and over half the book deals with how big the fish are north of New Jersey. Apparently he spent one day in Texas, at that place where "they bite every day," and there seems to be no photographic evidence of his observation that "it is often possible to kill a limit of ducks before ten o'clock in the morning and catch redfish and tarpon before going in to lunch." We do have pictures of the author, the author's wife, and other worthies alongside their victims or gazing out to sea at the ones that got away. The sections on the European and African coasts are very sketchy, even from the big game fisherman's point of view. The illustrations by Lynn Bogue Hunt consist of a colored frontispiece and chapter headings. All very fine, if your idea of fishing is to catch them as big as possible and get your name in a record book.

JOEL W. HEDGPETH

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AN INVESTIGATION OF OYSTER PRODUCING AREAS IN LOUISIANA AND MISSISSIPPI DAMAGED BY FLOOD WATERS IN 1945. *Special Scientific Report—Fisheries Number 8.*

By Philip A. Butler. United States Department of the Interior, Fish and Wildlife Service, Washington, D. C. Paper. ii + 36 pp. + 2 plates; text ill. 1949.

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PARASITOLOGY

MEDICAL ENTOMOLOGY. *Second Edition.*

By Robert Matheson. Comstock Publishing Company, Ithaca. $7.50. xii + 612 pp.; ill. 1950.

This second edition represents a considerable revision, and much of the new book is concerned with the tremendous advances made in this field since 1932. The author states that he has attempted to bring together all data available by the end of 1948.

There are 20 chapters. The first gives a brief historical account of the discovery of the transmission of certain diseases by arthropods, and the second is a general introduction to the Arthropoda. Chapters III–

XVI and XVIII deal with the orders and families of disease-transmitting arthropods; Chapter XVII is concerned with myiasis, Chapter XIX with poisonous and urticating arthropods, and Chapter XX with collecting, preserving, and mounting insects.

The various groups of arthropods are introduced with descriptions of their external and internal morphology, accounts which in the case of the ticks, the phylum Hexapoda, the order Diptera, and the family Culicidae are quite extensive. There are keys to certain classes, orders, families, genera, and to some species. These aids to identification are abbreviated, and although of use in student laboratory exercises, they are of limited value to the entomologist who wishes to make determinations without access to the special literature.

The essential features of the biology of the larger groups are summarized, and there are notes on the distribution, life cycles, and special habits of the more important species. The most valuable feature of the book is that it brings together most of the evidence for the incrimination of the vectors of disease. The list of proved arthropod vector species has increased greatly during the past 15 years. One addition to the second edition is a discussion of the arthropod-borne encephalitides, but unfortunately several of the viruses which have been isolated from wild-caught mosquitoes have been omitted. In a book of this size it would not be possible to summarize all of the voluminous literature on the transmission of malaria, yellow fever, and filariasis, and so tables are given listing the vector species, their distribution, and breeding habitats. The interpretation of this extensive literature is not easy, and one might question inclusion in the table of "principal vectors of malaria" such species as *Anopheles mangyanus* in the Philippines, *A. lungae* in Guadalcanal, and *A. pessoai* in South America, and the exclusion of *A. aquasalis*, *A. bellator*, and *A. cruzii* from the list of South American vectors. *Haemagogus spegazzinii spegazzinii* is not included among the list of yellow fever vectors. *H. splendens* and *H. equinus* are listed as having been found naturally infected, but no references are given. These species are known to be suitable laboratory vectors, and the finding of naturally-infected specimens would so increase their epidemiological importance that the work would merit a reference. The erroneous distribution given for some of the *Haemagogus* species is no doubt the result of the general state of confusion concerning the taxonomy of this genus.

With respect to control of the disease vectors, some species are dismissed with brief recommendations, while others are treated more extensively. Measures of control have been developing so rapidly that already this book is somewhat out of date. There is no reference in the index to chlordane, toxaphene, benzene hexachloride, or the pyrenones. Considerable space is given to the outmoded use of oils and Paris green as mosquito larvicides. Although DDT as an adulticide is discussed, the tremendous implications in the use of DDT and other residuals in control of malaria in rural tropical areas have been ignored. The standard arsenic dip formula for tick control is given, but there is no mention of the recent work on the newer dips, washes, and sprays.

It would be difficult to write a book that would summarize to everyone's satisfaction all of the various aspects of the rapidly expanding field of medical entomology. Matheson has attempted a compromise through brief discussions of some subjects which many readers may believe merit more extensive treatment. Nevertheless, this book will be a useful textbook for an introductory course in medical entomology.

LLOYD E. ROZEBOOM

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ILLUSTRATED LABORATORY OUTLINE OF VETERINARY ENTOMOLOGY AND HELMINTHOLOGY.

By J. H. Whitlock. Burgess Publishing Company, Minneapolis. $3.00 (paper). iv + 87 pp.; ill. 1948.

This manual is obviously designed to meet the needs of the author's own course, but could be adapted without much difficulty for any general course in veterinary entomology and helminthology. The current practice in laboratory manuals of providing drawings to be labeled by the student has been followed. These drawings, all redrawn or adapted from other authors, are large, reasonably accurate, and clearly reproduced by photo-offset. There are 31 full-page plates, consisting of 242 figures, mostly line drawings. Although there is no separate bibliography, specific references are given in the legends to the figures. The descriptive portion of the manual, reproduced by mimeoprint, is necessarily general and somewhat limited in scope. Some of the descriptive taxonomic material is presented in tabular form. A key to the mites of veterinary importance is given. It is perhaps unfortunate that keys to other groups, both arthropods and helminths, are not also included.

ALAN W. DONALDSON

ANIMAL GROWTH AND DEVELOPMENT

LEHRBUCH DER EMBRYOLOGIE.

By Walter Brandt. S. Karger, Basel. Sw. fr. 56.00. xii + 648 pp.; ill. 1949.

It is a curious anachronism that most current textbooks of human and mammalian embryology are so deeply concerned with "pure" morphology that they have failed to take advantage of the great body of literature dealing with experimental embryology and elucidating many of the morphogenetic processes. Some of the more recent editions of certain classical textbooks have attempted to compensate for this deficiency by including several chapters or portions of chapters describing some of the results of modern experimentation, but these sections tend to remain as islands separate and apart from the rest of the text. It is clear to cautious experimental embryologists that experimental results obtained on non-mammalian material cannot always be applied to the mammal. It is, however, only against a background of comparative embryology that many of the details of mammalian embryology fit into appropriate perspective, and only in the light of experimental data that the dynamic qualities of many of the morphogenetic processes can be appreciated. Yet there has been no really serious attempt to effect an integrative synthesis of comparative and experimental data with the morphological descriptions of embryogeny and organogeny which constitute the major content of the textbooks addressed to premedical and medical students. It is accordingly greatly to the present author's credit that he has made such an attempt.

In order to achieve this goal within the covers of a single volume of reasonable size, he has had to sacrifice some of the meticulous presentation of detail in which the fuller organological sections of Arey, Patten, and Hamilton, Boyd and Mossman excel. Furthermore, modern embryologists will sometimes disagree with some of his descriptions and interpretations, and in particular will question his presentation of the formation of the germ-layers in many of the vertebrate groups. His labeling, for instance, of the roof of the amphibian archenteron as "endoderm" will not be happily accepted even in relation to his mitigating statement that "das innere Keimblatt entwickelt drei Primitivanlagen: Die Chorda, das mittlere Keimblatt und die Darmanlage." His description of the formation of the layers in the chick is thoroughly incompatible with the results of the most recent experimental analyses on this form. His interpretation of mesoderm formation in *Amphioxus* is far closer to Hatschek's than to the more modern one of Conklin.

These are matters of detail, however, concerning which the student can draw his own conclusions by referring to the original literature, which this book will encourage him to explore. Any factual or interpretative deficiencies of the book are more than outweighed by the author's commendable contribution in coordinating modern comparative and experimental data with the classical material, and thus in presenting the mammalian embryo as an integrated and dynamically functioning whole.

Jane M. Oppenheimer

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Embryonic Development of the Platyfish (Platypoecilus), the Swordtail (Xiphophorus), and their Hybrids. *Bulletin of the American Museum of Natural History. Volume 94: Article 4.*

By William N. Tavolga. American Museum of Natural History, New York. 85 cents (paper). Pp. 161-230; ill. 1949.

This article represents a doctor's dissertation submitted to New York University. The greater part of it (45 pages) deals with the normal development of *Platypoecilus*, a viviparous poeciliid fish; six pages are devoted to a comparison of *Platypoecilus* development with that of *Xiphophorus* and of *Xiphophorus-Platypoecilus* hybrids. When embryonic stages of *Xiphophorus*, of *Platypoecilus*, and of their hybrids were compared, points of difference were found in the stage of initial pigment differentiation, in the stage of caudal fin differentiation, and in the rate of growth.

Jane M. Oppenheimer

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Recherches sur le Déterminisme de la Symétrie Bilatérale *dans l'Oeuf des Amphibiens. Suppléments au Bulletin Biologique de France et de Belgique, Supplément XXXI.*

By P. Ancel and P. Vintemberger. Laboratoire d'Évolution des Êtres Organisés, Paris. 1000 fr. (paper). iv + 191 pp. + 4 plates; text ill. 1948.

This communication includes a detailed description, discussion, and summary of an experimental analysis which the authors began in 1932 in an attempt to evaluate the degree to which the constitution of the virgin egg, the point of entrance of the spermatozoon, and gravity are involved in the determination of the plane of bilateral symmetry of the amphibian egg. Many of the results have been briefly reported in notes in the *C. r. Soc. Biol.*

The authors have been unable to find positive evidence of structural differentiation within the virgin egg responsible for determining either the position of entrance of the spermatozoon or of the plane of bilateral symmetry. They include, however, as positively demonstrated factors contributing to influence the position of the plane of symmetry, the point of entrance of the spermatozoon, the *rotation of orientation* of the egg, the inclination of the egg axis, the compression of the egg, and the *rotation of fertilization*.

The *rotation of orientation* they define as an early movement of rotation of the egg around its horizontal axis resulting from the action of gravity. In the eggs of *Rana fusca*, for instance, artificially activated according to the authors' methods, it occurs before the appearance of the perivitelline fluid, beginning, at 18° C., 10 to 15 minutes after activation and completed by 30 minutes after activation. The *rotation of fertilization* occurs later, beginning in comparable material one hour and 10 minutes after activation and ending an hour later. It brings the primary axis of the egg into an oblique position, its upper pole moving into what will be the ventral, its lower into what will be the future dorsal hemisphere. They claim to have demonstrated that the *rotation of fertilization* is not a mass movement of the egg as a whole, but rather a movement of the egg-cortex over the subjacent protoplasmic layers.

The authors believe that the point of entrance of the spermatazoon, the *rotation of orientation*, the inclination of the egg axis, and the compression of the egg act as preparatory factors contributing to influence the direction of the *rotation of orientation*, and they consider that their microscopic preparations indicate the manner in which these preparatory factors exert their influence. They conclude, however, on the basis of a long series of experiments varying these factors alone and in combination, that it is the *rotation of fertilization* which acts as the ultimate factor in determining the plane of symmetry, and they consider it to be the *rotation of symmetrization* of the egg.

Jane M. Oppenheimer

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Vision: *Its Development in Infant and Child.*

By Arnold Gesell, Frances L. Ilg, and Glenna E. Bullis, assisted by Vivienne Ilg and G. N. Getman. Paul B. Hoeber, Medical Book Department of Harper & Brothers, New York. $6.50. xvi + 329 pp.; ill. 1949.

This is the newest book from the Yale Clinic of Child Development, of which Arnold Gesell is director. It is essentially a verbal description of how infants and young children use their eyes in certain standardized test situations and in normal, everyday life. The authors appear to have two main theses: (1) visual behavior develops in an orderly sequence, much as other kinds of behavior do; (2) the development of visual behavior cannot be considered independently of the other types of behavior which mature at the same time. Both points are well substantiated.

On the whole, the book was disappointing to the reviewer. It is full of rich, beautiful prose, but is largely empty of solid, factual content. Read this sentence, for example: "His spatial domain is loosely organized, but his command of the meridians and dimensions of space is sufficiently firm so that his reactions are constructively fluid, rather than precariously instable"; or these, which incidentally keep recurring throughout the book: "FIVE is a nodal age. FOUR is fluid, but FIVE is in focus." Perhaps they may convey some meaning to other readers; but your reviewer found them, and many more like them, vacuous descriptions of human behavior.

There are 72 clear illustrations in the book, although some of these appear to serve no function other than to increase the printing cost. There is also a list of 55 Selected References at the end of the book. Several of these are actually mentioned in the text; it is difficult to see why some of the others were put on the list.

This is a particularly frustrating piece of work, because the authors evidently did some quantitative studies. In an appendix they discuss examination procedures which include retinoscopy, ophthalmoscopy, and measurements of acuity, phoria, accommodation, fusion, and so on. Surely *some* quantitative data must have been obtained. If the authors have such data, they have concealed them well. In short, don't read this book with the expectation that you will learn much about vision from it. If you want a pleasantly written description of what children do at various ages, then you cannot go wrong with this book. After all, it is written by authorities in the field.

A. Chapanis

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The Story of Life. *Nineteenth Edition.*

By Ellis W. Whiting; illustrations by Joan Walsh Anglund. Wilcox & Follett Company, Chicago, New York, and Toronto. $1.25. 48 pp.; ill. 1949.

This, a simple, straightforward book, now in its nineteenth edition, was designed to answer for young children the question where babies come from. It may be recommended for parents who may feel self-conscious about developing their own answers and who would like guidance on this point.

John Cushing

ANIMAL MORPHOLOGY

Les Glandes Endocrines Rétro-Cérébrales des Insectes (*Étude Morphologique*). *Supplément XXXII au Bulletin Biologique de France et de Belgique.*

By P. Cazal. Laboratoire d'Évolution des Êtres Organisés, Paris. 1000 fr. (paper). iv + 227 pp.; ill. 1948.

This publication represents a thesis presented to the Sorbonne for the degree of Doctor of Science. It is primarily a study of the gross structure and histology of the corpora allata and associated glandular and neural tissues. All major groups of insects are treated. The paper is profusely illustrated.

V. G. Dethier

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The Feeding Organs of Arachnida, Including Mites and Ticks. *Smithsonian Miscellaneous Collections, Volume 110, Number 10, Publication 3944.*

By R. E. Snodgrass. Smithsonian Institution, Washington, D. C. Paper. ii + 93 pp.; ill. 1948.

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Histology and Histopathology of the Eye and its Adnexa.

By I. G. Sommers. Grune & Stratton, New York. $12.00. xiv + 784 pp.; ill. 1949.

This book attempts to present, in a general and readable way, the fundamentals of a well known and exhaustively investigated field. It was prepared in response to student requests that the author's lectures be made available in permanent form. Indeed, each chapter resembles an informal lecture such as might be presented to an interested but uncritical group. Each is simple in form, without detailed discussion of controversial points. A notable feature of the format is found in the sections on literature, following each of the 20 chapters. Here findings not specifically mentioned in the text are summarized in brief paragraphs in small print, often single sentences. Immediately following these resumés are commendably extensive bibliographies covering the years 1920-47. This interesting device unburdens the text of frequent references to authorities (a weight which has rendered so many texts unreadable), while still offering accessible sources for further reading.

The 69 photographic illustrations are mostly low power magnifications. The quality of the specimens varies, but the reproduction is good. A 20-page index closes the book, which can be recommended as a readable treatment of its subject, acceptably accurate although not authoritative.

F. N. Low

EXTERNAL MORPHOLOGY OF THE PRIMATE BRAIN.

By Cornelius J. Connolly. Charles C. Thomas, Springfield, Illinois. $10.00. xiv + 378 pp.; ill. 1950.

It is a great pleasure to greet the publication of such a book as this. Drawn from comprehensive material, it is clearly written and beautifully illustrated with photographs, line drawings, and tabular material. It stays neatly within the confines of its subject matter, each topic being presented without undue brevity or excessive length. It fills a definite need in the literature on primate anatomy.

The Hrdlička collection in the U. S. National Museum was used for the study of fissural patterns in primate brains. All families among primates are represented in the 330 brains used. Most numerous are the apes and the catarrhine monkeys. The platyrrhine monkeys and the more primitive forms in the suborder Lemuroidea are less well represented. The findings are presented so as to collate well with subsequent chapters on human brain development and the brains of different modern races of man. A chapter on encephalometry describes an adaptation of the Schwarz Stereograph for brain measurement and presents some tabular data. Two chapters on endocranial casts describe the relationship of the cast to the underlying brain in the same individual in most apes and in modern man, serving as background for an interpretation of casts made from the skull fragments of fossil man. Other chapters deal with such topics as the relationships of cortical areas to sulci, and anthropoid and human sulcal relationships and homologies. There is an interesting foreword by James W. Papez.

One is impressed throughout by the author's skillful unemotional presentation of highly controversial topics. Such clearheaded consideration of facts, without any effort to push conclusions to one extreme or another, is a welcome ability (not to say innovation) in this particular field. Thus it becomes a convincing reality that the brains of the various genera of primates can, in most cases, be distinguished from one another by their external physical characteristics. All of them are clearly distinct from that of man, but point up the human brain as the end point of an increase in size and complexity of fissuration. The brains of fossil man apparently occupy an intermediate position encephalometrically between the apes and modern man, although their fissuration is uncertain. Among the races of modern man differences are those of frequency, individual measures overlapping. The racial identity of single individuals cannot be determined with certainty from the physical characteristics of their brains. This purposeful book, which could not have been prepared without long and painstaking effort, reflects great credit on the author. It is recommended without reservation.

F. N. Low

A TEXTBOOK OF NEUROPATHOLOGY *with Clinical, Anatomical and Technical Supplements.*

By Ben W. Lichtenstein. W. B. Saunders Company, Philadelphia and London. $9.50. xviii + 474 pp.; ill. 1949.

In this new textbook of neuropathology, the author has given a very good account of general disease processes within the nervous system and of pathological methods of detecting them, as well as excellent statements concerning clinical syndromes and disease entities. Since clinical neurological literature is so overburdened with syndromes named for their discoverers, it is a blessing to have a book in which all these syndromes, some of them most obscure, are brought together and given clinical and pathological delineation. There is an excellent supplement on neuropathological technics. Not the least helpful aspect of this textbook is the beautiful photography of both gross and microscopic sections. It is as good as that seen in prewar German publications and enhances the value of the text not a little. This should be a very useful book for students and practitioners as well as for professional pathologists.

WENDELL MUNCIE

LABORATORY MANUAL IN ANATOMY AND PHYSIOLOGY. *Second Edition.*

By Caroline E. Stackpole and Lutia C. Leavell. The Macmillan Company, New York. $2.00 (paper). viii + 216 pp.; ill. 1948.

This elementary manual is planned to accompany the *Textbook of Anatomy and Physiology* by Kimber, Gray, Stackpole, and Leavell.

DAVID B. TYLER

ANIMAL PHYSIOLOGY

PHYSIOLOGIE DE L'INSECTE: *Les Grandes Fonctions, le Comportement, Ecophysiologie.*

By Rémy Chauvin. L'Institut National de la Recherche Agronomique, Paris. 2500 fr. 619 pp.; ill. 1949.

To write a treatise in a young and rapidly expanding field is a tremendous task for any one person. This is particularly true in insect physiology. Since the publication of the *Principles of Insect Physiology* by Wigglesworth, eleven years ago, data on the physiology, chemistry, and pharmacology of insects have been accumulating at an ever increasing rate, due in large measure to the need for and the development of more effective insecticides. To assemble the scattered material, to integrate it with the more classical studies on insects and the vertebrates, and to present it in readable form to so diverse a group as students, teachers, and research workers who may be entomologists, physiologists, chemists, or insecticide manufacturers is indeed a task. Chauvin has done this in most admirable fashion.

The contents by chapters are as follows: the integument, molting and metamorphosis, digestion and nutrition, excretion, circulation (including the fat body and oenocytes), respiration, nervous system (including locomotion, reflexes, and taxes), sense organs and behavior, and growth and reproduction. The endocrines and intermediary metabolism are discussed under the processes in which they are involved in the various organ systems, e.g., hormonal control of color change under integumentary pigments, metabolic changes during metamorphosis under molting. Some of the less easily classifiable material, such as luminescence and the chemical constitution of the insect, is fitted in smoothly in not inappropriate places.

Typically, each chapter is introduced by a short, general description of the morphology of the organ system. This is followed by the detailed chemistry and physiology of the individual processes and parts of the system. An up to date bibliography ends each chapter. The strength of the book is greatly enhanced in two ways, in the opinion of the reviewer: first, more attention is given to methods and to biochemistry than is usual in a general physiology textbook; second, in each subsection a general statement is made and followed by typical examples in detail, usually in ordinal sequence. For example, the discussion of the osmotic pressure of the blood opens with two paragraphs descriptive of methods of determining the pressure in small volumes of liquid. This is followed by the general statement that the insect's osmotic pressure is generally higher than that of the mammal, with a paragraph each devoted to examples from five orders. Finally, with suitable figures and graphs the relation of osmotic pressure to the biotope and the details of osmotic regulation in three well known groups (Sigara, Culicids, Aedes detritus and Chironomids) are presented.

As would be expected in an undertaking of this magnitude, some chapters are exceedingly good, e.g., those on digestion and circulation, while others are less so, e.g., those on respiration and the nervous system. However, every aspect of the subject appears to be mentioned, and all of the material is clearly and concisely presented and well documented (e.g., chapter III, on digestion, contains 24 tables, 8 figures, and 258 references). This is a most welcome and valuable book, one which should prove to be of great usefulness to entomologists and physiologists alike.

GEORGE A. EDWARDS

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TEXTBOOK OF PHYSIOLOGY. *Tenth Edition.*

By William D. Zoethout and W. W. Tuttle. The C. V. Mosby Company, St. Louis. $4.75. 710 pp. + 6 plates; text ill. 1949.

This 34-year-old elementary textbook of physiology requires little introduction. The 10th edition is essentially the same as the 9th, reviewed earlier in this Journal (Q. R. B., *23:* 259. 1948). Additonal topics have been covered in this edition by the addition of some paragraphs on sleep, energy balance, water content, body temperature regulation, blood sedimentation rate, lymph glands, isotopes, and suppressor areas of the cerebrum. The general style and format are similar to those of earlier editions.

DAVID B. TYLER

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VITAMINS AND HORMONES. *Advances in Research and Applications. Volume VI.*

Edited by Robert S. Harris and Kenneth V. Thimann. Academic Press, New York. $7.80. xii + 435 pp. 1948.

The current volume of this valuable series contains eight reviews, two of which should be of rather general interest to theoretical biologists, namely, The B Vitamins as Plant Hormones (James and Harriet Bonner), and Vitamins in Microorganisms (J. M. Van Lanen and Fred W. Tanner). The Bonners have done a very satisfying piece of work in presenting data which give us "a partial understanding of the vitamin economy in the higher plant, and of the basic and general role of vitamins in the plant." This development has been made possible by the application of plant tissue culture techniques, since the higher plant, unlike the higher animals, is in general able to synthesize its own vitamins, making elucidation of the part played by vitamins by simple depletion experiments not possible with plants. These studies have revealed that certain of the B vitamins function in the plant as hormones.

The similarities in many of the biochemical processes of highly varied forms of life are further emphasized by Van Lanen and Tanner's review. "Conspicuous as a result of the progress of the last decade has been the growing realization that the vitamins have a general rather than a particular significance in biology. Particularly striking . . . has been the parallelism between factors essential in animal nutrition and those required for the growth of microorganisms. . . . Microbiology is certain to occupy a pivotal position in furthering our understanding of essential nutritional factors. . . . Aside from theoretical considerations, the elaboration of vitamins by microorganisms has become of increasing commercial importance. . . . On the basis of their sporadic distribution in microorganisms as well as their general lack of essentiality, ascorbic acid and the fat-soluble vitamins are readily separable from the regularly accepted members of the B complex. . . . Vitamins of the B group are universally distributed in microorganisms and occur there at a level appreciably above that commonly found in other biological specimens. Likewise, the majority of microbial species are capable of synthesizing these substances, in many instances making use of only the simpler forms of carbon and nitrogen." There are suggestions of correlations of anabolic and catabolic processes with vitamin formation and content.

The article on The Assessment of Human Nutriture (H. M. Sinclair) deserves the thoughtful consideration of the medical profession. This thorough and refreshing critique of attempts to evaluate human nutrition is forced to conclude that "man is a neglected animal." The volume also includes articles on the Chemistry of Pteroylglutamic Acid and Related Compounds (Brian L. Hutchings and John H. Mowat); Vitamin K (Henrik Dam); The Nutritional requirements of the Cotton Rat and Hamster (B. S. Schweigert); and Vitamins as Pharmacological Agents (Hans Molitor and Gladys Emerson).

E. C. Kendall has contributed a substantial 50 pages on The Influence of the Adrenal Cortex on the Metabolism of Water and Electrolytes, which is presented with a commendable background sketch of the normal distribution of electrolytes and some of the functional influences to which they are subject. In consequence, Kendall has been able to develop a more fundamental and rational approach than is sometimes shown by devotees of adrenal physiology. This review closes with a reference to a mechanism for the transport of ions across cell membranes. "The nature of this mechanism is as elusive as a gremlin, but when it is understood we shall know how a simple group on the steroid nucleus confers physiological freedom from domination by electrolytes."

It is a commentary on the economics of science in our time that of the ten American contributors only the Bonners hold appointments from an academic institution.

EVELYN HOWARD

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VITAMINS AND HORMONES. *Advances in Research and Applications. Volume VII.*

Edited by Robert S. Harris and Kenneth V. Thimann. Academic Press, Inc., New York, N. Y. $7.80. xii + 488 pp. 1949.

Twelve reviews, allotted seven and five to vitamins and hormones, respectively, illustrate in their several ways the varied functions of this type of essay: instruction, admonition, and goad.

Scarborough and Bacharach on vitamin P steer a wary course between those who deal with "vitamin P and chemical structure" and those who deny its existence. They show that a good part of the confusion surrounding this vitamin results from a failure to distinguish between capillary fragility and capillary permeability, and that the most unequivocal effects of the vitamin are on the former. In discussing the provitamins A, Zechmeister shows that variation in stereochemical arrangement alone may give a change in physiological activity of the same magnitude as that caused by a significant alteration in chemical structure. A stereochemical basis for the conversion of the provitamins to vitamin A is suggested. Factual data for the vitamin requirements of the guinea pig and the rat, respectively, supplement reviews in previous volumes of this series on the requirements of other laboratory animals. The role of thiamin in tissue metabolic reactions is reviewed by Jansen (Holland), and the basic flaw in the pellagra-causing maize diet is shown to be the absence of tryptophane (Krehl). C. M. McCay has written, in Diet and the Aged, an interesting and original review. The philosophy that "assumes little responsibility for (aged) citizens outside the family circle" does not appear to be limited to the Island of Okinawa, and the finest laboratories for the study of dietary deficiencies continue to be the various institutions of moral correction, and the asylums for the aged and insane.

Two excellent reviews of the chemistry of pituitary and other gonadotrophins (Li) and luteotrophin (White) emphasize the considerable body of new work in these fields. On the other hand, the posterior pituitary principles have provided a brisk pharmacology but altogether stagnant chemistry (Stehle). Articles on alloxan diabetes (Cabell Bailey) and infrared steroid spectrometry (Norman Jones and Dobriner) complete an interesting and valuable volume.

A few interpretations and misprints challenge the acuity of the reviewer. It should be emphasized that the figures (p. 99) for sedimentation of thiamine pyrophosphate enzymes refer rather to the particles with which the enzymes are associated than to the enzyme proteins themselves. A misplaced decimal gives pig FSH 44 per cent of hexosamine (p. 235). The same hormone gives resumption (not resorption) of follicular growth (p. 229).

H. N. CATCHPOLE

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PHYSIOLOGY IN DISEASES OF THE HEART AND LUNGS.

By M. D. Altschule. Harvard University Press, Cambridge. $5.00. xvi + 368 pp. 1949.

Although the author, in writing this excellent monograph, had in mind the needs of third and fourth year medical students, the book will undoubtedly be of great value also to those who are actively engaged in medical teaching, as well as to the more serious students of the subject. The teacher will find this an excellent source book for the preparation of lectures, while to the research worker it will be of particular value because of the completeness of the bibliography. Probably many investigators will take issue with Altschule on some of the interpretations he has made of their data; but, as the author points out, treatment of the data will also undergo revision in the future and by others.

The subject matter is treated in 12 different chapters wherein Altschule critically reviews the available data dealing with Chronic Cardiac Decompensation, Acute Pulmonary Edema, Cardiac Asthma, Angina Pectoris, Myocardial Infarction, Cardiac Arrhythmias, Pericarditis, Congenital and Acquired Cardiac Defects, Pulmonary Fibrosis, Chronic Pulmonary Emphysema, Bronchial Asthma, Pleural Effusion, and Pneumothorax and Pneumonia. The book is excellently written and well organized and can be recommended as a valuable addition to the library of any physiologist, physician, or investigator concerned with these problems.

DAVID B. TYLER

◆

HEMOLYSIS AND RELATED PHENOMENA.

By Eric Ponder. Grune & Stratton, New York. $10.00. viii + 398 pp.; ill. 1948.

It is now some fifteen years since the publication of a previous monograph on the erythrocyte by this author. There are many physiologists who have felt that a careful study of hemolytic phenomena would produce results of the greatest theoretical importance in understanding the cell surface. The years have passed and the work has been continued with commendable diligence. Therefore, it is somewhat disappointing to find that the goal of a real understanding of the cell surface seems as far away as before. Such a situation is not to be taken as implying any criticism of the author. On the contrary, the experimental data in this field are so voluminous and in several cases so reproducible that it is obvious that biological workers have passed beyond the present limits of our knowledge of the physics and chemistry of surfaces and of colloids. What would seem needed now is a greatly expanded program of research in colloid physics.

The first three chapters of the book deal with introductory ideas and with changes of shape either with or without volume changes. These chapters are largely an account of work which was completed by 1934. Chapter IV is on the cytochemistry and architecture of the erythrocyte. It includes much valuable tabular material on the chemical properties of the red cell and has a thought-provoking discussion of the state of hemoglobin in the cell under normal and sickling conditions. Chapter V is on the kinetics of hemolysis. Although students of chemical reaction kinetics may be somewhat dismayed by the rather complex formulations for lysis, it remains to be demonstrated that such formulations can be made more simply. There is a fairly thorough discussion of prolytic ion changes in cells, but the treatment of the cation permeability of cells is rather fragmentary. The author states that the subject of permeability is not within the scope of the book, but it is difficult to see how a thorough discussion of cation permeability, a subject previously much in dispute, can be omitted if one is to understand hemolysis. Chapter VI deals with the inhibition and acceleration of hemolysis. It contains a very detailed account of the effects of a large number of biologically important substances on hemolysis. It is here that it is particularly clear how difficult it will be to formulate ideas of surface structure that will explain the diversity of phenomena observed. The last chapter is a review of hemolysis in vivo and deals largely with clinical phenomena.

L. J. MULLINS

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RECENT PROGRESS IN HORMONE RESEARCH: *The Proceedings of the Laurentian Hormone Conference. Volume IV.*

Edited by Gregory Pincus. Academic Press, New York. $8.80. viii + 529 pp.; ill. 1949.

Although the subject matter of one conference may be insufficient to indicate a trend, it is interesting that fully three quarters of the papers given at the 1948 Laurentian Hormone Conference showed a direct or implicit involvement with topics of clinical research, and several with the growing use of the isotopic method in tracing, for example, changes in fat and carbohydrate metabolism (Stettin) or in the distribution of iodine (Keating and Albert; Seidlin). The human being as a hormone converter is represented in papers on estrogen and progesterone metabolism, in which interest continues unabated (Marrian; Heard and Saffron; Segaloff), while Samuels discusses the conversion of androgens at the tissue level. "Man a Machine" emerges from the extensive studies of the Harvard School (see diagram, p. 281); and equally, "Man not a Machine" (not an adding machine, at least) from those of the Worcester Foundation and the Allen Memorial Institute.

The somewhat perennial topic of antihormones brought out a discussion that turned largely on the concept of "pure hormones"—a concept to which the principles expounded by Pirie some time ago (*Biol. Rev.*, 15: 377. 1940) might profitably be applied. Stevenson described the remarkable fat rats of Yale which, like their literary forebear who:

> "grew his little paunch as fat
> As that of Doctor Luther,"

also seem to have had difficulties with their internal combustion. An urbane discourse, The Pancreas as Guardian of the Liver, presented a superior level concept, of the sort which, it seems, it should be a general objective of this kind of Conference to evoke.

Discussion of the papers provided a spirited commentary, and this volume, as a whole, is a valuable addition to endocrine literature. The printer's devil has evidently been seeing too many psychoanalytical movies; he turns up (p. 146) with a "prostatic group attached to a protein."

Contents: G. F. Marrian, Some Aspects of Progesterone Metabolism; R. D. H. Heard, The Metabolism of the Estrogens, Part I; R. D. H. Heard and J. C. Saffran, The Metabolism of the Estrogens, Part II; Leo T. Samuels, The Metabolism of Androgens by Tissues; Albert Segaloff, The Metabolism of Estrogens with Particular Emphasis on Clinical Aspects of Physiology and Function of Ovarian Hormones; James H. Leathem, The Antihormone Problem in Endocrine Therapy; Abraham White, Integration of the Effects of Adrenal Cortical, Thyroid and Growth Hormones in Fasting Metabolism; Dewitt Stettin, Jr., The Alterations in Metabolism Incident to Administration of Insulin, Adrenalin and Thyroid Substances, Studied with the Aid of Isotopes; C. H. Best, The Pancreas as Guardian of the Liver; George W. Thorn and Peter H. Forsham, Metabolic Changes in Man Following Adrenal and Pituitary Hormone Administration; Gregory Pincus, Hudson Hoagland, Harry Freeman and Fred Elmadjian, Adrenal Function in Mental Disease; R. A. Cleghorn and B. F. Graham, Manifestations of Altered Autonomic and Humoral Function in Psychoneuroses; James A. F. Stevenson, Effects of Hypothalamic Lesions on Water and Energy Metabolism in the Rat; Rulon W. Rawson and William L. Money, Physiologic Reactions of the Thyroid Stimulating Hormone; F. Raymond Keating, Jr., and A. Albert, The Metabolism of Iodine in Man as Disclosed with the Use of Radioiodine; S. M. Seidlin, Radioiodine as a Diagnostic and Therapeutic Tool in Clinical Medicine.

H. R. Catchpole

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The Cycle in the Gambel Sparrow.

By Barbara D. Blanchard and Mary M. Erickson. University of California Press, Berkeley and Los Angeles. $1.50 (paper). iv + Pp. 255–318 + 1 chart; ill. 1949.

The senior author of this paper is well known for her work on two forms related to the Gambel sparrow, *Zonotrichia leucophrys nuttali* and *Z. l. pugetensis*. The race, *Z. l. gambeli*, studied in the present publication is a winter resident in California and migrates north to British Columbia and Alaska to breed. As in the previous study, the cyclic histological changes in the male gonads were extensively studied during the period of winter residence and the various stages of recrudescence were compared and correlated with the activities of the birds. Leydig cells were found to be absent from specimens collected between September and early January. Their subsequent appearance preceded by four weeks any visible change in the tubules; it is emphasized that their appearance forms the first indication of testicular recrudescence. These cells undergo an enormous increase in number up to the time when mature sperms appear; it was calculated that the total volume of glandular intertubular tissue was 130 times as great in the breeding testes as in gonads beginning to recrudesce. It is suggested that this parallel increase between Leydig cells and the resurgence of sexual behavior may be taken to indicate that they are the source of the male sex hormone.

The first appearance of the Leydig cells is designated as Stage 2. One bird at Davis was in Stage 2 on January 5; two others collected on the same day were still in the winter condition. On January 20, of seven specimens sectioned, one was in Stage 3, one in Stage 1, and five in Stage 2. At Santa Barbara the earliest date for Stage 2 occurred on January 8. Comparison of the initial date for these changes with external factors of day length, temperature, humidity, and solar energy leads the authors to conclude that such factors play insignificant roles, if any at all, in the physiological processes of testis recrudescence and that recrudescence must perforce be an inherent rhythm. This conclusion is similar to the one reached by the senior author in her former study.

Since so much experimental evidence has accumulated to show that manipulation of light does influence the gonad cycle, it will be of great interest to discover wherein lies the discrepancy between experimental birds and those exposed to natural conditions. Although the effect of increasing light is denied in the present paper, the argument is not entirely convincing. It is pointed out that the average increase in light was only 0.9 minutes per day from the time of the winter solstice through January, and that from December 22 to January 5 the absolute increase was of the order of 6 minutes, that the majority of days during this period were cloudy, rainy, or otherwise obstructive to the total possible sunlight. The latter argument is certainly not valid, considering the fact that as little as 0.04 foot candles of illumination has been shown to cause some testicular activity. Even the darkest day has considerably more light than this. The 15-day interval with only a seemingly trifling increase in daylength might still be sufficient to initiate Stage 2. English sparrows on just a 10-hour day have been found to have dividing spermatogonia, a point well beyond the Stage 2 described here. Therefore, although photoperiodicity may not have as simple and direct an influence on gonad recrudescence in free wild birds as has been believed, it is still not a factor to be ruled out peremptorily without conclusive evidence to the contrary. The major weakness of this report lies in the evaluation of external environmental conditions. Otherwise it is an excellent and valuable contribution, one which taken together with the previous study provides considerable insight into the physiological ecology of closely related birds, and emphasizes once again that external morphology is not always a reliable criterion for distinguishing subtler and more important differences in physiology and behavior.

HENRI C. SEIBERT

THE ADRENAL CORTEX. *Annals of The New York Academy of Sciences, Volume 50, Article 6.*
By R. Gaunt, G. E. Bergner, J. S. L. Browne, H. W. Deane, R. I. Dorfman, W. J. Eversole, P. H. Forsham, Roy O. Greep, A. G. Hills, D. J. Ingle, E. C. Kendall, E. J. Kepler, L. A. Lewis, I. H. Page, G. Pincus, F. T. G. Prunty, G. Sayers, M. A. Sayers, G. W. Thorn, E. H. Venning, and G. W. Woolley. The New York Academy of Sciences, New York. $3.00 (paper). Pp. 509–678; ill. 1949.

This authoritative series of papers is the result of a conference on the adrenal cortex, held jointly by the New York Academy of Sciences and the New York Academy of Medicine, March 21 and 22, 1948. Introductory notes on the history of the adrenal cortical problem are presented by Robert Gaunt and J. W. Eversole. There follows a straightforward presentation of studies on pituitary-adrenal interrelationships by G. and M. Sayers, with evidence for an inverse relationship between the blood concentration of adrenal hormone and the pituitary output of adrenocorticotrophic hormone. E. C. Kendall discusses the difficult syntheses of the adrenal steroids, with their still unsatisfactory yields. Evidence that the biological properties of synthetic and natural 11-dehydrocorticosterone are nearly identical is presented by L. A. Lewis and I. H. Page, R. I. Dorfman, and E. H. Venning. A critical survey of representative methods for the bioassay of adrenal hormones is given by R. I. Dorfman.

D. J. Ingle surveys the role of the adrenal cortex in organic metabolism in his characteristically thoughtful manner. Ingle concludes that:

> "The thinking of many of us in the adrenal field has become too rigidly channelized during the past few years. It is common to describe adrenal physiology in terms of electrolyte and organic metabolism as though they are completely unrelated functions, electrolyte metabolism being controlled by 11-desoxycorticosterone and organic metabolism being controlled by the C-11-oxygenated steroids. The story is not this simple . . . there is considerable overlapping of effects, and there is a great deal of evidence that there are basic relationships between the distribution of inorganic ions and the metabolism of organic compounds which relate to adrenal cortical functions. . . . We have spoken of end results as if they were the processes of action. We know none of the reactions into which the cortical hormones enter to bring about their metabolic effects. . . . Not all of the effects of the cortical hormones upon the viability and vigor of the animal can be defined in terms of what is now known of the metabolic effects of these hormones. . . . The most important and remarkable advances in the adrenal field have been the isolation, identification and synthesis of several biologically active compounds. . . . Now the new techniques of enzymology and isotope chemistry may be the tools required to probe into the processes by which the cortical hormones produce their effects. In addition to techniques, new and broader concepts are needed. I hope there will remain a place for physiologists . . . who will, at appropriate intervals, remind the chemist that the organism functions as a whole."

R. O. Greep and H. W. Deane, in discussing the cytology and cytochemistry of the adrenal cortex, summarize interesting evidence against the frequently reiterated view that the cells of the cortex are ordinarily undergoing periphero-central migration. The production of cortical tumors following gonadectomy in mice is described by G. W. Woolley. Data on the urinary excretion of corticoids and 17-ketosteroids are presented by E. H. Venning and J. S. L. Browne. These two groups of urinary metabolites are presumed to represent different adrenal functions, and, from their excretion rates under various conditions, it is suggested that these functions may vary independently of one another. Gregory Pincus discusses adrenal cortical function in stress as the beginnings of a systematic analysis of mental disease in terms of hormonal dysfunction. Clinical studies in Addison's disease are presented by G. W. Thorn and others, and Cushing's disease is discussed by E. J. Kepler. Altogether, the volume is a stimulating presentation of a considerable range of contemporary work on the ubiquitous adrenal.

EVELYN HOWARD

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LE SYSTÈME NERVEUX SYMPATHIQUE. *L'Avenir de la Science, Number 29.*

By Paul Chauchard. Gallimard, Paris. 490 fr. (paper). 364 pp. 1949.

In this book the author describes the sympathetic nervous system along broad lines and in a manner characterized chiefly by lack of interpretative inhibition. The first part contains, in addition to a short historical chapter, an anatomical account and a description of general function and pharmacology. The second part is devoted to internal sympathetic mechanisms, considering bioelectric, chemical, and physical phenomena. Sympathetic regulation of organic function and its maladjustments are covered in the last part. Some of the interpretations are far from general acceptance, at least among scientists who rate disciplined thinking a virtue. The inclusion of motor cells in dorsal root ganglia is bound to disturb anatomists, and few physiologists will be comforted by sympathetic reflexes mediated, partly antidromically, over separate branches of the axon of a single cell. Such conceptions unfortunately characterize the book. The few illustrations are poorly drawn. The bibliography, admittedly not complete, contains only 26 items, mostly general in nature. This book offers little or nothing to the serious student of the sympathetic nervous system.

F. N. LOW

ANIMAL NUTRITION

TRACE ELEMENTS IN FOOD.

By G. W. Monier-Williams. John Wiley & Sons, New York. $6.00. viii + 511 pp.; ill. 1949.

The author is in charge of chemical researches in foods in the Ministry of Health, England. His book contains 28 chapters, and some discussion of 32 elements. It is, however, not well planned and has serious defects. The term trace elements has come to be used to designate those elements which are of metabolic significance in normal plant and animal metabolism. They are essential nutrients. The author includes discussion of these, but gives fully as much space to a consideration of elements which frequently occur in small amounts in foods, and which, so far as is known, are foreign and poisonous materials, primarily of interest to the food inspector and toxicologist. Either group of elements alone might well be treated in a book of this size, but they should not be listed indiscriminately in one volume. The treatment accorded the elements is very uneven. Twenty-five per cent of the book is devoted to copper, lead, and zinc. Almost as much space is given to tin, arsenic, antimony, selenium, and iron. Other elements are quite inadequately discussed. An example is cobalt, for which there is but one reference to any publication as recent as 1944. The bibliographic references to older literature will be useful, but for recent publications the reader will have to seek elsewhere. Much space is devoted to analytical methods for the quantitative estimation of certain elements. It is a mistake to try to include discussions of biological significance, toxicology, and analytical methods for so many elements in a volume of this size.

E. V. MCCOLLUM

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TOMORROW'S FOOD. *The Coming Revolution in Nutrition.*

By James Rorty and N. Philip Norman; foreword by Stuart Chase. Prentice-Hall, New York. $3.50. xiv + 258 pp. 1947.

This is a thought-provoking book which everyone should read, for everyone must eat. Again and again the authors, one of whom is a journalist and the other a physician, call attention to the sobering fact that Americans are not eating the most healthful food and that this is because of various reasons—one, and most important, the over-processing of grains for the manufacturing of flour and various processed breakfast foods. They also show that commercial handling practices destroy much of the natural vitamin content as well as other health-giving food qualities. They emphasize the nutritional inadequacies of the so-called "enrichment" of foods. Recalling the campaign of Harvey W. Wiley, who championed the food needs of American consumers, Rorty and Norman show that the time is already ripe for another Wiley, a man with sufficient courage to defy the commercialism of food processing and advertising. The authors complain that the public does not learn through magazines all that it might about nutrition, because of the domination of the editorial policies of periodicals by the advertisers. They also rightly emphasize the strength of custom in determining food habits and practices, and the fact that this is not entirely dependent upon commercialism and advertising. This is exemplified in illiterate Asia by practically universal milling of rice by all the natives in all rice-growing regions, a practice which constitutes a nutritional impoverishment even though hand milling is not as deleterious as machine processing. The two appendices, How to Eat Sensibly without Vitamin Charts, and Bibliography of Recommended Books, are useful adjuncts.

ROBERT L. PENDLETON

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OUTLINES OF FOOD TECHNOLOGY. *Second Edition.*

By Harry W. von Loesecke. Reinhold Publishing Corporation, New York. $7.50. viii + 585 pp.; ill. 1949.

The author has included a surprising amount of information on the preparation, handling, and processing of fruits, vegetables, dairy products, meats, poultry, fish, shellfish, grains, fats, oils, sugars, starches, nuts, spices, relishes, essential oils and extracts, beverages, confectionery, jams, jellies, preserves, and certified dyes. The discussions cover raw materials, equipment, machinery, packaging, preserving, freezing, storing, and marketing. The author is a chemist in the U. S. Department of Agriculture, and is obviously thoroughly familiar with his subject. He acknowledges the assistance of 14 men whose names are familiar to all who know anything about food technology. The book is to be highly recommended.

E. V. McCollum

◆

Diet in Relation to Reproduction and the Viability of the Young. *Part I. Rats and Other Laboratory Animals. Commonwealth Bureau of Animal Nutrition. Technical Communication Number 16.*

By F. C. Russell; with a Foreword by I. Leitch. Commonwealth Bureau of Animal Nutrition, Rowett Institute, Bucksburn, Aberdeen, Scotland. 6s. (paper). 99 pp.; ill. 1948.

It is pointed out that the earnings of animal husbandry are seriously reduced by losses due to inefficiency of the breeding stock, to poor lactation, and to low vitality of the young. There are many evidences that inadequate dietaries may be implicated. Since adequately planned and controlled studies for clarifying the problems involved are not available for farm animals, the authors undertook to assemble all available data from laboratory animal experiments which have a bearing on the subject, and to interpret these data in the hope that such a study might shed light on problems of reproduction and the rearing of young in animal husbandry. They first reviewed this field of inquiry fifteen years ago. The present study was based upon an examination of all abstracts in volumes 1–17 (1931–1948) of *Nutrition Abstracts and Reviews*. Stock diets, food consumption and energy requirements, protein, carbohydrate, calcium, phosphorus, vitamin D, magnesium, iodine, iron, copper, manganese, sodium, chlorine, potassium, aluminum, boron, fluorine, selenium, essential fatty acids and fat, vitamin A and carotene, vitamins E and K and the "grass juice factor," vitamin C, the B-complex components and choline are examined in their possible relation to fertility and viability of young. There is an interesting summary, a bibliography of 414 titles, and an index. This thorough inquiry into the meaning of recorded experiments with laboratory animals with reference to reproduction, etc., will be invaluable to all nutrition investigators and animal husbandmen.

E. V. McCollum

BIOPHYSICS

Applied Biophysics. *Survey of Physical Methods Used in Medicine. A Symposium.*

Edited by N. Howard-Jones. Chemical Publishing Company, Brooklyn. $6.75. viii + 293 pp.; ill. 1949.

A symposium of articles on physical methods used in medicine, previously published in the British Medical Bulletin, and written by well known medical physicists of England, this small volume consists of terse summaries of several diverse and important fields to which physicists have contributed. Except for the articles on drug action and the mechanics of brain injuries, the book deals primarily with applications of electronics, heat, and ionizing radiation to diagnosis and therapy of cancer and related diseases.

Titus C. Evans

◆

Radiology Physics. *An Introductory Course for Medical or Premedical Students and for All Radiologists. Second Edition.*

By John Kellock Robertson. D. Van Nostrand Company, New York, Toronto and London. $5.00. xviii + 323 pp.; ill. 1948.

This second edition is a revision of a very readable and non-mathematical introduction to the physical principles underlying the use of x-ray generators and radium applicators. The most evident additions are terse summaries of principles involved in atomic energy and in super-voltage particle accelerators. The book begins with a review of pertinent principles of electricity and magnetism. This is followed by illustrations of these principles in the generation and control of high voltage to produce ionizing radiation. The most practical part of the book, from the standpoint of the radiation-biologist, is the comprehensive discussion of the properties of x-rays and their interaction with matter. The last part of the book deals with radioactivity, transmutation, and uranium fission.

Titus C. Evans

◆

Infrared Determination of Organic Structures.

By H. M. Randall, R. G. Fowler, Nelson Fuson, and J. R. Dangl. D. Van Nostrand Company, Inc., Toronto, New York, London. $10.00. v + 239 pp.; ill.; 354 plates. 1949.

Spectroscopy, using visible and ultraviolet light sources, has long been a useful means to the characterization of biologically important compounds. Infrared spectroscopy has not been developed to the same extent because of inadequate sources and recording devices, although the chemical industries have successfully employed available instruments for the qualitative and quantitative identification of compounds and mixtures of compounds. The authors, realizing the need for detailed information in this increasingly important field, have compiled a mass of data, much of it from their own researches, into a form useful for those who would employ infrared spectroscopy in the determination and identification of molecular structure.

The book may be divided roughly into three major aspects which, however, are not arranged consecutively as to chapters. The first considers the possibilities and limitations of infrared spectroscopy in chemical analysis, the instruments, techniques, and practical applications, and the methods of recognizing and interpreting specific structure groups. The second aspect, covering two chapters, is concerned with cataloguing the information which deals with the "empirical structural assignment for the double-bond region" and the "structural assignment for theoretically analyzed molecules." Some 600 double-bond compounds are catalogued for absorption assignment in the 6 micron region, and some 350 molecules are theoretically analyzed as a point of departure for further investigations. The remainder of the book lists half-tone absorption spectra of 355 organic compounds.

As the authors point out, the data presented deal largely with compounds of the aliphatic and phenyl-substituted aliphatic families, and represent a portion of their contribution to problems of penicillin structure and synthesis. The compounds discussed, therefore, are of limited scope. The usefulness of the book goes beyond this, however, for it provides a basis for spectroscopic work on a variety of compounds and by a variety of workers.

C. P. SWANSON

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BIOCHEMISTRY

ANNUAL REVIEW OF BIOCHEMISTRY. *Volume XVIII. Edited by J. Murray Luck, Hubert S. Loring and Gordon Mackinney. Annual Reviews, Stanford, California.* $6.00. x + 739 pp. 1949.

The hardy perennial of summarization in the vast field of biochemistry continues to fulfill its function in this, the 18th volume of the series, in which reference is made certainly to most of the important papers published over a period of approximately one year. The editors have maintained the standards set in previous volumes. They have selected significant chapter headings, keynoting the broad topics for review. They have been able generally to attract eminently competent authors. To quote from the Preface: "While the writing of reviews of one sort or another is becoming a literary and intellectual experience which falls to the lot of almost every scientist sooner or later there is nothing in the accumulated experience that makes the task easier. In these *Reviews* especially it is admittedly arduous. A strenuous effort is made to maintain them at a critical level." As to the necessity of transferring some special subjects of a biochemical nature to other members of the family of *Annual Reviews*, the editors have reassured the reader as follows: "It is, however, our hope and confident expectation that all investigations of a fundamental character, whether the subject of research be a plant, an animal, or a microorganism, will continue to find their place in the *Annual Review of Biochemistry*."

The topics reviewed and the respective authors are: Biological Oxidations (P. W. Preisler and F. E. Hunter, Jr.); Proteolytic Enzymes (E. L. Smith); Nonoxidative, Nonproteolytic Enzymes (K. Myrbäck); Carbohydrate Chemistry (D. J. Bell); Chemistry of the Lipids (J. A. Lovern); Chemistry of Amino Acids and Proteins (H. P. Lundgren and W. H. Ward); Nucleoproteins, Nucleic Acids, and Derived Substances (J. N. Davidson); Metabolism of the Lipids (A. L. Lehninger); Chemistry of Neoplastic Tissue (E. Boyland); Metabolism of Proteins and Amino Acids (A. Neuberger); Intermediary Metabolism of Phosphorus Compounds (F. Lipmann and N. O. Kaplan); Carbohydrate Metabolism (H. G. Wood and V. Lorber); Mineral Metabolism (Fluorine and Other Trace Elements) (F. J. McClure); Chemistry of the Hormones (A. Wettstein and F. Benz); Fat Soluble Vitamins (P. L. Harris); Water Soluble Vitamins (E. L. R. Stokstad and T. H. Jukes); Nutrition (A. Keys); Metabolic Inhibitors (R. J. Winzler); Chemistry of Antibiotics (O. Wintersteiner and J. D. Dutcher); Insect Biochemistry (V. B. Wigglesworth); Nitrogenous Constituents of Plants (A. G. McCalla); Organic Acids of Plants (T. A. Bennet-Clark); Mineral Nutrition of Plants (C. H. Wadleigh). There are adequate author and subject indexes.

LESLIE HELLERMAN

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INTRODUCTION TO PHYSIOLOGICAL AND PATHOLOGICAL CHEMISTRY. *With Laboratory Experiments. Third Edition.*

By L. Earle Arnow, with an introduction by Katharine J. Densford. The C. V. Mosby Company, St. Louis. $4.00. iv + 595 pp.; ill. 1949.

This is a highly condensed presentation of such subjects as organic chemistry, biochemistry, nutrition, and clinical laboratory chemistry. The book has been written for the training of nurses, and it is probably very adequate for this purpose. One must regret that such a training course has to be so condensed, and that so little basic information can be presented. The book is not suitable for the training of biologists.

L. J. MULLINS

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ADVANCES IN CARBOHYDRATE CHEMISTRY. *Volume 4. Edited by W. W. Pigman and M. L. Wolfrom. Academic Press, New York.* $7.80. x + 378 pp. 1949.

The fourth volume of this series maintains the high standard of the preceding three volumes. It contains 10 chapters that cover various specialized aspects of carbohydrate chemistry.

The first article, The Structure and Configuration of Sucrose (I. Levi and C. B. Purves), is a masterly review of the chemical work on sucrose since the early nineteenth century, tracing the work to the present time, when knowledge of the configuration of this sugar is practically complete. Also included is information concerning the biochemical synthesis of sucrose.

The second contribution, Blood Group Polysaccharides (H. G. Bray and M. Stacey), deals with blood group substances. These authors have summarized the efforts of the last two decades to elucidate the chemical nature of blood group substances, which are largely carbohydrate in nature and of the mucoprotein type.

A detailed account of Apiose and the Glycosides of the Parsley Plant is given by C. S. Hudson. The knowledge of parsley glycosides is treated historically, and their proof of structure is discussed in detail. C. Neuberg, in an article entitled Biochemical Reduction at the Expense of Sugars, is concerned with the phytochemical reductions of sugars by various classes of compounds, such as aldehydes, ketones, diketones, quinones, and others.

An informative article on the Acetylated Nitriles of Aldonic Acids and their Degradation has been prepared by V. Deulofeu. It deals chiefly with the Wohl degradation procedure, in its different variations and modifications.

Wood Saccharification (E. E. Harris) is an interesting discussion of the production of sugar from wood waste. This process has claimed the attention of chemists for many years. J. Boeseken, in his contribution on The Use of Boric Acid for the Determination of the Configuration of Carbohydrates, has reviewed the work on the interaction of boric acid with sugars, and points out the valuable knowledge that has been gained from these reactions regarding the configuration of carbohydrates. R. Lohmar and R. M. Goepp, Jr., in The Hexitols and their Derivatives, give an account of all the known sugar alcohols, their occurrence, preparation, and physical and chemical properties.

The article Plant Gums and Mucilages (J. K. N. Jones and F. Smith) is an excellent summary of the complicated structure of these compounds. The knowledge gained in that subject is chiefly the result of the efforts of the English investigators, Haworth, Hirst, Smith, and Jones, who have used the methylation procedure.

The last article, one on the Utilization of Sucrose (L. F. Wiggins), is concerned with processes for converting sucrose into compounds which can be used for industrial purposes.

Like the previous volumes of the series, this one is international in scope. Of the 10 articles, three contributions have come from England, one from Canada, one from Holland, one from Argentina, and four from the United States.

W. Z. Hassid

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HEMATIN COMPOUNDS AND BILE PIGMENTS. *Their Constitution, Metabolism, and Function.*

By R. Lemberg and J. W. Legge. Interscience Publishers, New York and London. $15.00. xxvi + 749 pp.; ill. 1949.

This is a welcome and important addition to the bibliographic literature of biochemistry. The authors have incorporated within their domain the molecular, physical, and biological chemical properties of and relations among the porphyrins, bile pigments, hematin compounds, hemoglobins, and other metalloporphyrinoproteins, including hematin enzymes such as cytochromes, catalase, and peroxidase. Withal, they have contrived the miracle of comprehensiveness coupled with critical and discriminating analysis and treatment of numerous and diverse topics. Several of the fields under review naturally are in flux, and some of the material is controversial. Such material seems to have been treated with reasonable objectivity and fairness.

With satisfactory clarity the authors have referred throughout to the contributions afforded by the use of indispensable physical chemical approaches that have illuminated much of the subject matter. The principal methods include spectrophotometry, potentiometry, and magnetochemistry. There is a useful preliminary chapter entitled Methods of Investigation, credited to J. P. Callaghan. Obviously, any success in the treatment of many aspects of the difficult material reviewed rests upon those structural studies of the porphyrin compounds that constitute one of the outstanding achievements of "classical" organic chemistry in the first half of this century. This underlying field perhaps was not intended to be a primary consideration in the present volume, but it may be stated that the authors' employment of pertinent structural data is adequate.

It is impracticable to discuss here in any detail the large number of related topics of practical and theoretical importance that constitute the meat of this treatise. The subject matter obviously is of interest to the biologist, who no doubt will approve the authors' respect for comparative biochemistry. The medical investigator will find many points of interest, including commentaries on methods of estimating hemoglobin, functional adaptation in mammalian respiration, bile pigment estimation and metabolism, etc. The chemist will be intrigued by what has been accomplished through penetrating application of appropriate physical chemical techniques to a problem in metallo-coordination stemming from biology. The enzyme specialist will enjoy the discussions of respiratory catalysts, and, as suggested by the authors, will consult the recent papers by Britton Chance for the latest word on catalase and peroxidase.

The bibliography, comprising pages 655 through 726, contains some 3200 citations.

Leslie Hellerman

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Pathologie des Kohlehydratstoffwechsels.

By E. Frank. Benno Schwabe & Company, Basel; Grune & Stratton, New York. Fr. 24.–. 342 pp. + 7 plates; text ill. 1949.

This is a comprehensive and well arranged book, intended primarily for the diabetic patient. It has successfully brought together the theoretical aspects of diabetes and its clinical applications, with emphasis on the latter. The causes, symptoms, and treatment of the disease are discussed. A great deal of attention is devoted to food selection and diet, as well as to the function and use of insulin. The facts are presented in historical perspective, the discussions being based on the experimental data of various investigators in the field. On the whole, the subject is treated in a scholarly manner.

In spite of the conscious attempt on the part of the author to make his subject comprehensible to the layman by its simplicity, the abundant use of highly technical formulae and medical terminology makes it doubtful whether the patient can derive much benefit from the book. For this reason the reviewer is of the opinion that this work is more suitable as a physician's manual.

W. Z. Hassid

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MICROBIOLOGY

Jordan-Burrows Textbook of Bacteriology. *Fifteenth Edition.*

By William Burrows; with the collaboration of Francis Byron Gordon, Richard Janvier Porter and James William Moulder. W. B. Saunders Company, Philadelphia and London. $9.00. xx + 981 pp. + 4 charts; text ill. 1949.

The successive editions of this well-known book have provided a changing picture of the science of bacteriology for over 40 years. The current edition maintains the excellence and up-to-dateness of its predecessors. While a large portion of the volume is devoted to the classification, pathogenicity, etc., of the various forms, the inclusion of recent work on the genetics, cytology, physiology, and nutrition of bacteria and bacteriophages serves to draw the subject matter into closer relationship with similar studies on higher organisms. The chapter on bacterial variation, however, does not receive the attention which it deserves. Many of the important papers dealing with this topic are not cited, and the significance of the techniques of bacterial genetics, as they apply to physiology and variation, is largely passed over. Except for this, the volume gives its rather large subject a well balanced and comprehensive treatment.

C. P. Swanson

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HEALTH AND DISEASE

Peace or Pestilence. *Biological Warfare and How to Avoid It.*

By Theodor Rosebury. Whittlesey House, McGraw-Hill Book Company, New York, Toronto and London. $2.75. viii + 218 pp.; ill. 1949.

Peace or Pestilence is a clear and easy-reading appraisal of biological warfare (BW) which admirably succeeds in its prime purpose of stimulating and informing the general reader. The contents are divided roughly into three parts. The first portion, which presents a survey of bacteriology and its place in society, provides the background of scientific information necessary for the layman's understanding of the subject matter of BW treated in the succeeding chapters. Finally there are chapters devoted to discussions of the political and ethical problems raised by this potential weapon for mass destruction.

The manner of presenting the technical and scientific data is skillful. The reader is not surfeited with fact and detail, but rather is fed an economical modicum of scientific information that sustains his interest, while logically supplying the factual basis for understanding each succeeding phase of the problems discussed. The reviewer caught only a few, and these unimportant, errors of fact and misspellings. For example, the molecular weight of botulinal toxin quoted is too low, and the Waring *blendor* is spelled *blender*.

The style of writing is light but not superficial, and can serve as a good example of popular science writing by the scientist. It suffers only from the author's occasional inability to resist the temptation to turn a neat phrase. These slips result in a sacrifice of strict historical accuracy, or let an ineffective prejudice intrude into an otherwise worthy argument. They also offend the more well-informed and sensitive reader as examples of "being talked down to.". Thus in emphasizing the enormity of present day warfare that does not limit the slaughter to the warrior, the author remarks "How old-fashioned the ancients were!" (p. 179). But this gives our ancestors too much credit. I am sure that the sacking of cities and indiscriminate slaughter of civil populations were acceptable military policy in ancient as well as recent times. In this regard our forefathers have set us no good example. Then the "average" congressman is disparaged in a way that cannot win that "average" congressman to the author's point of view (p. 146). In a book attempting an objective study of a serious social problem, while maintaining a definite point of view, a slip of this sort is particularly unfortunate. Certainly a task the author has set himself is to convince the "average" congressman and those citizens of similar attitudes of the reasonableness and logic of the book's theses. This cannot be done by publicly announcing mistrust of the "average" congressman's intellectual capacity. As another example we note (p. 173) the author's reminder to the reader that the temperature of the blood of scientists is the same as that of other humans.

The subject of BW deserves the serious attention of all persons. International bodies concerned with maintaining the peace are duty bound to give the subject consideration. This book, as the lone recent and available discussion of BW, deserves reading by a wide public of both laymen and scientists. It has a genuine contribution to make to the understanding and thinking of any person with the least sense of social responsibility. One would, therefore, hope for widespread sale and discussion of the book.

The endorsement does not mean that the reviewer would agree with the author in all respects on matters of judgment and opinion. In a democracy any well-written and honest book on a subject of great social import, which promises to increase the public interest and knowledge, deserves the support of the critic.

And so now a few words of criticism. The practical difficulties of making BW an offensive weapon are not neglected by the author, but he feels confident that these difficulties will yield to science and ingenuity (p. 116), and so justifies his view that BW presents society with the choice of peace or pestilence. But in so rationalizing the title of the book the author has not consistently applied his logic. The potential destructiveness of BW can only be realized practically if defenses against it lag far behind. Logically, one can also appeal to science and ingenuity to overcome the practical difficulties of defense against BW. The author is inconsistent and weakens his cause by stating: "... defense against BW as a whole is pitiably weak, so weak that some of us, civilian or military, cannot find much comfort in its prospect." (p. 135).

The question of the potential offensive value of BW is important, because one must weigh its destructiveness relative to atomic warfare. Should we press for agreement among the nations not to use atomic weapons when the BW weapons remain uncontrolled? Can the nations afford not to agree on control of atomic fission until agreement on BW weapons is possible? Is the relative threat to humanity by atomic warfare greater than BW? *Peace and Pestilence* gives each type of weapon the same value. There is room for serious disagreement with this point of view. It is not entirely a matter, as suggested by the author, of the physicists being more afraid of the bacteria and the biologists more afraid of the atom. The principles of specific defense against BW are available from the sciences of immunology and epidemiology. There is no specific defense against the exploded atomic or H bomb. The nature of the long-term biological effect of using these diverse weapons on large populations is sufficiently different to give the biologist's fear of atomic fission the greater weight. If the nations do not in our generation agree to abandon warfare as an instrument of national policy, as a generation we will suffer the consequences of our folly, irrespective of the nature of the weapons used. But if atomic weapons are used the sins of the fathers may in unexpected and genetic ways be visited for untold generations on our progeny. As an optimist, I am hopeful that even though our generation fails to maintain the peace, some future generation will succeed. Let us endow this generation with the knowledge of our folly, and inevitably some of our debts, but let us leave it free to procreate at a handicap no greater than the natural spontaneous mutation rate.

It is a measure of the pace of recent events that this book, published less than a year ago, might be somewhat differently phrased if it were written today. To the statement of "... the flourishing state of science in the Soviet Union" (p. 132) might be added "except for the science of genetics." This is no superficial change. One wonders if the agreement among the nations on the control of atomic fission would not come to pass, or be speeded up, if the leaders of the Soviet Union were a little more convinced of the reality of the findings of genetic science. The development of the H bomb would possibly have modified the author's equation of the dangers of BW and atomic warfare. Then certainly there would have been considered a discussion of the meaning of the Soviet Union's recent unilateral moves to make propaganda capital out of Japanese BW efforts.

CARL LAMANNA

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PINK PILLS FOR PALE PEOPLE.

By F. William Saul. Dorrance & Company, Philadelphia. $2.50. 204 pp.; ill. 1949.

Some years ago a reviewer in these columns pointed out what a valuable contribution to folk lore a history of quack medicine would be. It would also be quite exciting reading. The work here under discussion is no history of quackery, but it is so surcharged with historical material that no one who is eventually to undertake such a work can afford to overlook it. The author makes it quite clear that there are two types of quack medicine. First, there is that large body of superstitious belief which has slowly accrued through the centuries and which has invested with specific medicinal powers almost every object which can conceivably be ingested. This type of quackery is interesting because it has not been perpetrated as a deliberate fraud—there is no pecuniary advantage to be gained by the propagation of the belief that cabbage is a specific for cancer of the breast, or that wax from the ears is good against whitlows, whatever those may be. The reviewer recalls the suggestion made by an elderly female relative when he was suffering from typhoid fever, that he should bind to the sole of each foot half of a freshly killed pigeon. No, this body of belief is the product of honest but ignorant persons who have imagined themselves cured of various diseases (which they may never have had) by the application of these bizarre medications, and perhaps some of the claims on behalf of them are not without foundation. For instance, it seems quite reasonable that an infusion of toe-nails taken internally might be an efficient emetic, especially if the patient is aware of what is being administered.

A few centuries ago this sort of quackery was indistinguishable from orthodox medicine. The works of Galen are a peculiar mixture of legitimate medicine and quackery, and the Badianus Manuscript, a legitimate medical work, reads strangely like *The Long Lost Friend*, which is probably the most famous compendium of quackery in history and even today circulates widely in the more backward areas of the nation. Strangely enough, the author has completely ignored this classic, though he might have derived much aid and comfort from it.

The other type of quack medicine is that resorted to by unscrupulous exploiters of the inborn desire of *Homo sapiens* to take medicine, a desire which, according to Osler, is the most important difference between man and the other animals. Among these quacks the author mentions by name Elisha Perkins, S. R. Chamley, Gerald Macaura, and many others whose names are now forgotten and who profited from the gullibility of those who have contracted the sort of diseases not commonly talked about in public, or who have exposed themselves to infection yet are not sure that they are infected. This type of quackery is ancient. The author is able to quote an historical record from the fourth pre-Christian century.

On the cover of this volume are facsimiles of the advertising of Lydia E. Pinkham's Vegetable Compound, Piso's Cure for Consumption, and various other "cures" for goiter, obesity, failing eyesight, and constipation. These advertisements bring back vivid memories of the days when song books and almanacs published by Ayer, or by Hostetter, could be obtained free every January from the country drugstore. On the title page of each almanac was the figure of a man whose anatomical structures were in some mysterious way correlated with the signs of the zodiac, and whose lower abdomen had been surgically operated on to reveal certain structures that would not otherwise have been in evidence. It so happened that in those days a certain popular manufacturer of boys' clothing designed a pair of trousers that unbuttoned in the same pattern as that of the abdomen of the man in the almanac, and just as children of today adopt the speech of Amos and Andy and the mannerisms of Howdy Doody and Popeye the Sailor Man, just so did those of an earlier generation go around with their pants unbuttoned to resemble the figure in the almanac. Fortunately the reviewer was never caught at it.

The author supplies ample proof that other things besides medicine are subject to quackery. For instance, he quotes many literary effusions of a pseudo-poetical nature, all of which are bad and most of which are terrible. These could very appropriately be called quack poetry. Similarly the numerous drawings incorporated in the book illustrate what might well be designated as quack humor. And finally, even quackery itself may be quacked. The numerous details which the author gives us to show how the art of dentistry and other surgical arts have been practiced in the past are quite authentic. Such practices cannot be considered genuine quackery; they are only quack quackery.

JOSHUA L. BAILY, JR.

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HOSPITAL TRENDS AND DEVELOPMENTS, 1940–1946.

Edited by Arthur C. Bachmeyer and Gerhard Hartman. The Commonwealth Fund, New York; Geoffrey Cumberlege, Oxford University Press, London. $5.50. xiv + 819 pp.; ill. 1948.

The increasing complexity of the hospital's organization and the broadening scope of its functions make it practically impossible for the busy administrator to keep abreast of the literature pertaining to his field, particularly when it is realized that articles of interest to him appear in a wide variety of journals relating to hospital care, medicine, public health, business organization and management, law, sociology, psychology, and many additional related fields. Thus, in order to provide the hospital administrator, or the student of hospital administration with a fairly complete and accessible reference to the pertinent literature on the subject, the editors have combed a wide variety of journals, and have selected and reprinted here some 150 papers covering the most important aspects of hospital trends and developments for the period 1940–1946. The papers have been edited only very modestly, resulting in minor losses of certain illustrative materials where considerations of space made it necessary. The papers have been arranged in chapters relating to such specific topics as Hospital Service, Medical Staff Organization and Relationships, Hospital Organization and Management, Outpatient Department, Nursing Education and Nursing Service, Medical Social Service, Medical Records, Hospital Construction, Food Service, Public Relations, and Group Hospital and Health Insurance. In addition to such bibliographic footnotes as are included in the individual papers, the editors have listed at the end of each chapter a series of references for further reading on the topic under consideration.

Although there is no index of subjects or authors, the detailed table of contents serves adequately for reference to the volume. The work will undoubtedly prove itself to be as valuable as its companion piece, *The Hospital in Modern Society*, which appeared in 1943.

B. AUBREY SCHNEIDER

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MEDICINE FOR MODERNS. *The New Science of Psychosomatic Medicine.*

By Frank G. Slaughter. Julian Messner, New York. $3.50. x + 246 pp. 1947.

This is no textbook in psychosomatic medicine but a rather successful "attempt to present to the lay reader in nontechnical language a survey of this, the newest, most fascinating field of medical science." The author's point of view has developed through many years of surgical practice and was strongly influenced initially by Adolf Meyer, whose student Slaughter was, and later especially by the work of Franz Alexander and H. Flanders Dunbar.

Slaughter covers an extensive range of psychosomatic topics beguilingly headed: Medicine For Moderns; Understanding Your Autonomics; The Anatomy Of Fear; Forming The Personality; The Case Of The Blushing Stomach; The Discontented Colon; Doctor—My Heart!; Hostility And Hypertension; Harnessing The Blood Stream; Coronary Thrombosis—The Price Of Success; Diabetes And Dementia Praecox; Asthma—Allergy And Emotion; Some Call It Migraine; My Love Is Rosy Red; Emotions And The Endocrines; Fibrositis—The Fashionable Backache; Woman! The Enigma Explained; The Reluctant Lover; Accidents Don't Happen By Accident; Psychometry—Testing For Type; Psychotherapy—Treating Diseased Emotions; Newer Methods Of Treatment; Is This Operation Necessary?; Destiny and Disease; Revolution In Medicine; For Parents Only.

The author's style is in keeping with the appeal of chapter headings and is enlivened with an abundance of case histories neatly focused for telling effect. Nevertheless, readability has been achieved at the expense neither of authenticity nor accuracy. The evidence which the author brings to the reader is cogent and convincing. Psychological medicine cannot—but further should not—be the exclusive province of the psychiatrist. Slaughter's case against "medicine" which considers only the disease and not the patient is in itself a positive contribution to the layman's medical thinking. This book will certainly contribute to a more widespread and a more informed popular understanding and appreciation of the dynamic interrelations between physical health and psychological well-being.

JOSEPH C. FRANKLIN

PSYCHOSOMATIC MEDICINE. *The Clinical Application of Psychopathology To General Medical Problems. Second Edition.*

By Edward Weiss and O. Spurgeon English. W. B. Saunders Company, Philadelphia and London. $9.50. xxx + 803 pp.; ill. 1949.

This edition is essentially the same as the first, except for minor changes in arrangement and the incorporation of some new material, particularly a chapter on psychosomatic diagnosis. The first edition has been reviewed by one who is apparently friendly disposed to the general subject and ideas covered in this text. (Q. R. B., 19: 72. 1944). Since the present reviewer is not so inclined, potential customers are referred to that earlier review.

It is clearly evident, even to the casual reader of the history of medicine, that the faith in the psychic origin of disease is too deep rooted to be easily changed. Few will deny the fact that psychological factors are of importance *in the management* of the sick, for it is well known that such factors affect the behavior and capacities of individuals during the course of any illness. It also is reasonable to assume that in cases where there is a predisposition to certain organic lesions, permanent structural alterations or functional impairment may be precipitated by an emotional crisis. This last is to be qualified by defining "predisposition" as an actual, though in some instances, not easily detectable, physical defect. However, a critical examination of the results of studies to date do not justify the conclusion that psychological or psychopathological factors are of direct importance in the etiology of somatic disabilities. The available evidence offered in support of the formula that "psychological disturbance → functional impairment → cellular disease → structural alteration" is anything but convincing.

To be sure, the authors of this treatise repeatedly make statements that appear to indicate a qualified acceptance of the above formula. For instance, in their introduction we read: "It seems probable that future investigations will permit us to say that it is possible for a psychological disturbance to antedate the functional alteration," (pp. 4–5) and in evaluating the emotional factor in the etiology of organic heart disease, they emphasize: "*The mere discovery of unpleasant circumstances in the life situation of an individual is no indication of emotional complications and still less of the psychogenic origin of the difficulty.*" (p. 275). This is a very reasonable observation. And, again we read, in their discussion of the possible role of psychogenic factors in causing essential hypertension: "*Please do not understand, however, that we are maintaining that psychological factors are the only ones of importance in hypertension or even that they are fundamentally responsible.* What we are urging, rather, is that they are a set of factors that are important to the patient with hypertension and that their modification often results in benefit to the patient regardless of whether the blood pressure figures are lowered or not." (p. 341). This is not considered unsound medical practice, for apparently very few find fault with therapeutic procedures that, although not curing hypertension, at least leave the patient in a pleasant frame of mind.

In criticizing the suggestions of Trueta and his coworkers ("that the principal etiological factors responsible for hypertension will be found in the central nervous system even in the human mind itself"), Weiss and English write: "We doubt that a complete understanding of essential hypertension lies within the province of psychological medicine . . . " (p. 305). However, they continue in the same sentence " . . . but we share with the authors of this remarkable work the enthusiasm for a unique approach . . . "

There are many more such sentences, all of which if taken at face value would indicate a reserved or qualified acceptance of many of the doctrines adhered to by the psychosomatic enthusiasts of today. But, standing in contradiction to these statements there are just as many that support such doctrines. For example, in the section dealing with the psyche and hypertension, and directly after their criticism of Trueta's theories given above, they state: "Therefore, it may be said that in spite of the organic nature of experimental hypertension, the psyche is not absolved as a factor in the etiology of hypertension in man. It is conceivable that a disturbance in the circulatory function of the kidneys could have its origin in impulses of central nervous origin." (p. 305). The subject discussed in this section and in the sentences immediately preceding this statement leave little doubt but that by "central nervous origin" they mean psychological factors.

Finally, their discussion of the etiology of peptic ulcer is most revealing. Starting with the statement that "The term psychosomatic can be used without hesitation in connection with peptic ulcer because today even the most organically minded physician recognizes the importance of 'emotional factors' in ulcer cases" (p. 433)—they develop the theme with the words: " . . . We are confronted with imposing evidence that psychic factors are of the greatest importance as a cause of peptic ulcer . . . " There are other examples of such about faces, but the foregoing will serve for the purpose of this review.

Now, what makes up the "imposing evidence" that supports the premise that psychic or personality factors are of "greatest importance" in the etiology of peptic ulcer or, for that matter, any other organic disease or permanent structural alteration? It appears that the available evidence offered in support of such views is obtained from the psychiatric examination of a few small groups of individuals suffering from certain organic dysfunctions. From these findings the authors of such studies usually conclude that a high correlation exists between psychological or psychopathological factors and the disease in question. In examining the results of such studies and considering the contention that there is a specific etiological relationship between psychic factors and permanent structural alterations, it is necessary to bear in mind that what has been only factually established is that among a small portion of individuals suffering from an organic disturbance some neurotic individuals can be found. A relevant but unanswered question is whether such neurotic trends are absent or occur less frequently in those who do not suffer from the disability. Also, there is no information offered as to the incidence of the disease under study among the distinctly neurotic members of the general population.

Another argument which has very often been advanced by psychosomatically inclined investigators is based on the well-known observations that certain normal psychic manifestations, such as fear and rage, are capable of producing transitory alterations in the functioning of certain autonomically supplied systems. A priori, it would seem reasonable to assume that if emotional factors are capable of producing a transitory elevation of blood pressure, surely they must be of importance in producing the permanent pathological condition. The weakness of this argument is that there is no sound evidence to show that such transitory responses to normal emotional disturbances, even when repeated quite frequently, will produce permanent changes or alterations in function of a healthy organ.

In ancient Babylonia there was a group of priestly doctors who occupied a high position in the state. They were primarily concerned with internal, mental, and nervous diseases, and it seems that a popular specialty among them was that of foretelling events by the appearance of the liver. For this reason, and because they believed that all the emotions, as well as the ills of the body, could be ascribed to that organ, they were known as "Hepatoscopists." The philosophy underlying the procedures of those ancient Chaldean priest doctors was probably inherited from the early Sumerians or possibly from a still more primitive group. Regardless of its ultimate origin, the idea has survived through the ages and can also be observed in practice today in the methods of the Siberian shaman and the African witch doctor, whose dogma, interestingly enough, is that "in all cases of disease in which no blood is showing the patient is suffering from something wrong in the mind." The general idea can also be found in the procedures of the Iroquois medicine man, who based much of his treatment on the principle that every illness is a "desire of the mind." It is tempting to suggest that present day practitioners of that ancient art be called "psychoscopists." This would differentiate them from those psychiatrists who confine their studies to diseased or ailing minds. In this new category, I am sure, a place might also be found for the psychoanalysts. I hasten to explain that the suggestion of this new terminology does not infer any close similarity between the procedures of the uncivilized Siberian shaman or Iroquois medicine man on the one hand, and those of the highly cultured and expensively educated modern practitioners of the ancient art on the other, for it is well known that the shaman uses a drum and the Indian medicine man a magic rattle.

David B. Tyler

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Heart. *A Physiological and Clinical Study of Cardio-Vascular Diseases.*

By Aldo A. Luisada; with a foreword by Herrman L. Blumgart. The Williams & Wilkins Company, Baltimore. $10.00. xii + 654 pp. + 1 chart; text ill. 1948.

Several of the best known textbooks on cardiology (*Diseases of the Heart* by Sir Thomas Lewis and *Clinical Heart Disease* by Samuel A. Levine) are notable for the personal biases and interests of the authors. Luisada's new book is an even more personal presentation. He brings to bear on the subject not only his many years of work on graphic registration, pharmacology, cardiac drugs, and numerous studies of pathological mechanisms, but also much European thought not otherwise readily available in this country. This makes the reading of the book something of an adventure.

The introductory section includes chapters on development and structure, on physiology, and on technical study of the cardiovascular system. The anatomy is classical and is presented with a rather heavy hand. Controversial material, such as the work of Glomset who decries the presently accepted anatomy of the conduction system, is avoided. The chapter on physiology embraces many unusual concepts, the most noteworthy being the origin of the dichrotic wave of the pulse in the active contraction of the peripheral arteries in response to systolic distention. A large portion of the technical study is devoted to phonocardiography and other rather unfamiliar graphic registration techniques. Electrocardiography is described in a rather perfunctory fashion with, for example, only mention in a footnote of the valuable unipolar limb leads. The choice of material in this section at once recommends the book very highly to a small number of persons interested in the pulse wave and similar phenomena and confuses the average reader. The mention of many of the newer techniques, including electrokymography and cardiac catheterization will, however, interest many. Unfortunately, the extensive chapter bibliographies are without titles and are not arranged by subject, hence are useful only in close conjunction with the text.

The bulk of *Heart* is clinical and covers examination of the patient, modes of origin of cardiovascular disease, pathological mechanisms such as those of cardiac failure and pulmonary edema, and an anatomical arrangement of disease states. Material is presented with relatively little discussion and a notable tendency to dogmatism. The text is clear and straightforward, with well chosen illustrations, and should appeal to practitioners. It contains, in addition, enough unusual material and strongly voiced personal ideas to be both enjoyable and stimulating.

E. Converse Peirce, 2nd

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Lectures on The Liver and its Diseases. *Comprising the Lowell Lectures Delivered at Boston, Massachusetts, in March 1947.*

By H. P. Himsworth. Harvard University Press, Cambridge. $5.00. xiv + 204 pp. + 1 plate; text ill. 1948.

Diseases of the liver are a challenge to the clinician since that organ possesses such a reserve of function that damage is usually far along before clinical signs of impairment become evident. Furthermore, the relation of deranged function of the liver to a particular lesion is difficult, as similar symptoms may result either from gross alterations in structure or from lesions so subtle that they do not produce any apparent structural alterations. Nevertheless, if the initial lesion can be recognized, therapeutic measures may be instituted at early stages with better chances of obtaining effective results. In this monograph, based on a series of lectures delivered at the Lowell Institute in 1947, Himsworth has arranged his subject matter in groups and sequences so as to correspond fairly definitely to the pathological sequences observed both in man and experimental animals. By so relating one pathological form with another, the possibility of recognizing the initial lesion of each category is enhanced.

In grouping and cataloguing the available knowledge of liver diseases, Himsworth has revealed the large gaps in our knowledge. The book is divided into 12 chapters and covers the following principal subjects: The Types of Liver Injury and their Structural Consequences; The Vascular Factor in Liver Injury; Nutritional Factors in Liver Injury: Experimental; Nutritional Factors in Liver Injury: Human; Noxious Factors Causing Liver Injury; The Syndromes of Hepatic Failure; The Clinical Classification of Liver Disease; Infiltrations of the Liver and Post-Infiltrative Fibrosis; Parenchymatous Hepatitis; Cholangio-Hepatitis, Obstruction to the Bile Ducts, and Biliary Diffuse Hepatic Fibrosis; Circulatory Disorders; Focal Lesions; and Cancer of the Liver. This authoritative book is well written and undoubtedly will stimulate further experimental studies on problems of great clinical and physiological interest.

David B. Tyler

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Public Health and Hygiene: *A Students' Manual. Fourth Edition.*

By Charles Frederick Bolduan and Nils William Bolduan. W. B. Saunders Company, Philadelphia and London. $4.25. x + 423 pp.; ill. 1949.

The fourth edition of this standard textbook follows much the same pattern of organization and presentation as the earlier editions, with such necessary revisions and additions as were necessary to cover recent scientific advances, particularly in the fields of antibiotics, insecticides, herbicides, and radioactivity.

The text is divided into five parts, dealing respectively with: (1) general considerations of public health; (2) the more important communicable diseases; (3) the more important non-communicable and chronic diseases and conditions; (4) community hygiene; and (5) public health administration. Among the general principles of public health considered in Part I are such topics as the historical development of the public health movement, the transmission of communicable diseases, the life histories of certain insects directly related to health problems, the principles of nutrition in health and disease, and the socio-economic factors in public health. The section on communicable diseases is concerned with the causative organisms, the modes of infection and spread, as well as control measures relative to many conditions including tuberculosis, pneumonia, influenza, diphtheria, scarlet fever, typhoid, typhus, malaria, yellow fever, dysentery, and the venereal diseases. Such non-communicable and chronic diseases as diabetes, heart disease, and cancer are discussed in relation to our aging population in Section III. Sections IV and V present a description of the administrative set-up for public health activities on federal, state, and local levels, and some of the basic problems which are dealt with by such facilities, e. g., sewage disposal, water and food supply and inspection, industrial hygiene, school health, public health nursing, and health education. The volume is well adapted for a senior high school or junior college course in hygiene. It is well illustrated and documented, and carries indices of subjects and authors.

B. Aubrey Schneider

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LANGUAGE AND LANGUAGE DISTURBANCES. *Aphasic Symptom Complexes and Their Significance for Medicine and Theory of Language.*

By Kurt Goldstein. Grune & Stratton, New York. $8.75. xii + 374 pp.; ill. 1948.

Over a period of almost 45 years, Goldstein has thought and written much about various aspects of the diagnosis and treatment of aphasia. This book represents a synthesis of his work and his ideas. Goldstein's expressed purpose is twofold: (1) to develop a theory of language disturbances that is broad enough to account in detail for known symptom-complexes; and (2) to outline diagnostic and therapeutic procedures that are consonant with this theory and useful in prognosis and retraining.

Part I is concerned with a study of the origin of aphasic conditons. Four categories are adduced: (1) symptoms representing defects of performance (Jackson's "negative symptoms"), which Goldstein calls *direct*; (2) symptoms caused by the separation of an undamaged area from a damaged area (Jackson's "positive symptoms"), which Goldstein calls *indirect*; (3) symptoms which are effects of the damaged area upon the rest of the nervous system, called *secondary*; and (4) symptoms which reflect the operation of mechanisms to protect the personality from catastrophe. Within the framework of these categories, Goldstein postulates an "organismic approach to aphasia," that is, "the trend of the organism to actualize itself, its 'nature,' its capacities, as well as possible." Accordingly, "it follows that every individual speech-performance is understandable only from the aspect of its relation to the function of the total organism in its endeavor to realize itself as much as possible in the given situation." Herewith, the nature and extent of the indirect, the secondary, and the protective symptoms carry importance in detailed diagnosis and, more particularly, in spontaneous restitution and in retraining. Goldstein outlines the essential differentiation between the organismic and the more classical approach (labeled "atomistic"), which is keyed to anatomic-physiologic concepts of integrated cortical centers, in a tightly argued discussion of verbal imagery, the differences between concrete and abstract language, and the localization of language and language disturbances. His arguments are supported by analyses from the fields of semantics, psychology, and linguistics. His findings are specified in a survey of a wide variety of language disturbances in pathology.

Part II presents a series of detailed case-reports (including diagnostic tests and their interpretations), analyses of expressive, receptive, central, amnesic, and transcortical aphasias, and a brief section on treatment. In general, Goldstein's nomenclature is conservative and eclectic, and is designed to emphasize the need for comparison and correlation among symptom-complexes.

This is a difficult book, but a stimulating one, provocative of thought and argument in a field wherein much has been written, wherein theory is widely divergent, wherein clinical practice is often sketchy, and wherein much detail is as yet undemonstrated and undemonstrable. Goldstein is well aware of many of the shortcomings of an attempt to bring about a marriage between the empiric and the theoretic in the field of language disturbances. He writes with forbearance from a wealth of clinical experience and creative construction, and with a focus on the premise that the brain both affects and is affected by its substrata, in whole and in part. The study of language in all its aspects is a tremendous activity in these days, and to this study Goldstein has made a real contribution.

William G. Hardy

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Twentieth Century Speech and Voice Correction. *Edited by Emil Froeschels. Philosophical Library, New York.* $6.00. x + 321 pp.; ill. 1948.

The declared purpose of this book is to present "to persons scientifically and/or practically interested in speech and voice correction the latest developments in this field." Both design and execution fall short of that goal. Together with his own various and extensive contributions, the editor has called upon 18 colleagues to express themselves. This they have done within no clear framework, and with a startling and frequently disconcerting array of styles and perspectives. The essayists follow their individual bents through the intricacies of theoretical construction, diagnostic practice, and therapeutic procedures related to language disorders, auditory disorders, and a smattering of vocal training and reading disability. Some undertake to teach, others to outline clinical procedures, others to analyze theory and practice by case-presentation, and still others to argue the merits of particular attitudes and practices. The general effect is a spottiness that is not redeemed by some excellent essays. There is no orderly progression through a complex field that is itself a synthesis of several clinical and research fields. Because of the variety of subject matter and points of view, this book should prove most useful to the specialist who already knows his way in speech correction; for the newcomer or the casual inquirer, it provides neither analysis nor synthesis and would be quite misleading as a picture of speech and voice correction today.

William G. Hardy

PSYCHOLOGY AND ANIMAL BEHAVIOR

My Monkey Friends. *Second Edition.*
By Mrs. Charles E. B. Russell. Adam & Charles Black, London. 7s. 6d. 127 plates + 19 plates. 1948.

The author of this small, popular book was for several years a volunteer helper at Albert Schweitzer's hospital in Equatorial Africa and has traveled extensively in many parts of the world. She writes entertainingly of her trips, and especially about the many infant monkeys and apes which she has at times adopted with tender care and which often accompanied her in her traveling. Judging from the 31 small photographs, these pets have included gorillas, chimpanzees, several species of guenons, and a mandrill. From these pages it is very evident that companionship, plenty of exercise, and, of course, a suitable diet are essential for the welfare of these social and active animals and that given such conditions all these primates form fond and trusting attachments to a sympathetic human master—at least while they are young. The last chapter, On Keeping Monkeys, is written on the basis of long experience and its sound advice will profit all owners of simian pets.

A. H. Schultz

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Experimental Studies in Psychodynamics. *A Laboratory Manual.*
By Donald W. MacKinnon and Mary Henle. Harvard University Press, Cambridge; Geoffrey Cumberlege, Oxford University Press, London. $5.00 (paper). x + 177 pp. 1948.

In this manual, MacKinnon and Henle have undertaken something that was very badly needed and extremely difficult to do. They have tried to bring down to the level of the classroom the pioneer attempts to investigate problems of personality and motivation by means of experimental techniques. The success of the book is due to the experience and ingenuity of the authors. Its weaknesses are the result of our inadequate knowledge of the field that they attempt to explore.

The manual deals for the most part with experiments designed originally by Lewin and his associates. Most of these experiments are classical, in the sense that they led to new information and to new areas of investigation and are now known as mileposts in the development of personality theory. Still, these experiments are so enmeshed in clinical techniques that it is difficult to be sure where experimental control begins and where the art of the clinician ends. A few examples will suffice.

In the prefatory instructions to the student the authors have written the following: "Acting as experimenter in these studies consists in large measure of playing a role. Before coming to the laboratory it is important that the student study his part so that in the actual experiment he can play it with ease and confidence."

On one occasion the authors have written: "The experimenter begins by friendly conversation with the subject, in order to establish rapport with him. It is important that good rapport be established, since the experimenter must obtain maximum cooperation from the subject. But it is equally important that the distance between the experimenter and the subject be maintained. Since the subject is to be led to believe that his intelligence is being tested, the experimenter must maintain the serious attitude of an examiner throughout the experiment." Again: "By means of preliminary friendly conversation with the subject, the experimenter creates a free and unrestrained experimental situation."

The instructions in experiment after experiment are of this order. In many cases there is almost no assistance given by the authors to the potential experimenter in exact techniques for accomplishing what he is told to accomplish in the way of establishing a social situation. This is a very serious weakness in the method of presentation. Without modification in this regard by the instructor who uses the manual, it is hard to see how these experiments could serve a very good pedagogical purpose. On the other hand, if we assume that such modifications are made, this should be a very useful book. In any case, the authors are to be congratulated for having broken ground in this new area.

WILLIAM C. H. PRENTICE

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THE PSYCHOLOGY OF TEACHING. *Second Edition.*

By Asahel D. Woodruff. Longmans, Green & Company, New York, London and Toronto. $3.00. xiv + 272 pp.; ill. 1948.

This is a book in educational psychology, which makes it immediately suspect to many psychologists and to many educators. As the author himself points out, much of what is called educational psychology can be criticized as being too far removed from the actual problems of day-to-day teaching. In many instances college courses labeled "educational psychology" are only imperceptibly different from courses in general psychology—and instances can be reported in which an instructor meets both classes in the same room at the same hour, using a single text and a single set of lecture notes. On the other hand, the experimental or the clinical psychologist may ask what material has been uncovered or synthesized that justifies this special category. Is it psychology or is it pap?

It can certainly be argued that a teacher's ability to guide the development of his pupils can be the better for having absorbed the material presented in psychology courses of the non-educational brand. Many are able to deepen their insight into personality dynamics (their own as well as their pupils') through courses in clinical psychology. The intelligent use of evaluative devices will be most difficult without a solid foundation in the theory and practice of testing and in the area of individual differences. The experimental literature in the field of learning can be a sound starting point for the growth of a teacher's own practical skills in the classroom, and some knowledge of the physiological and developmental aspects of emotional behavior should be a helpful adjunct in understanding the whole pupil. Perhaps even some information concerning receptor and perceptual processes could be of value to the teacher in elementary and secondary schools. All this would require an undergraduate major, or even an advanced degree, in psychology, leaving courses in "professional education" to fill in a few miscellaneous chinks and odd hours. Perhaps boards of education, however, to say nothing of professional educators and education students themselves, might feel this to be as inadequate a training for teaching as would be just the preclinical program for physicians. Hence the effort, illustrated in this book, to extract just those items of psychology that may be clearly pertinent to the classroom, and to show how they may be applied by the skillful teacher.

The only trouble is that, when so extracted, many of the items appear to the non-educational psychologist to be so far removed from clinical and experimental psychology as to be non-psychology! Not that what is said necessarily controverts the findings of the laboratory or the clinic. Rather, so much of it could have been said by any alert schoolman with a minimum of strictly psychological training. And as soon as the statements are presented without the imperative specifications and qualifications of the scientific setting, there is danger that they become either misleadingly simple or meaninglessly ambiguous. It is difficult to defend, disprove, or even to apply objectively such a proposition as "It is psychologically sound to assume that each student will do his work unless there is something wrong with him that needs attention" (p. 178).

The critical question is: Will this book be of value in education classes? It could be. The general outline, the logic of organization, the realistic projects presented with several chapters, all suggest that the author, in his own educational psychology classes, develops the themes in a way to gratify both the educator and the psychologist. But an instructor with a less complete background and a limited imagination will be unable to clothe with operational meaning the well-sounding words. In short, placed in less certain hands, this will be merely "another educational psychology textbook."

FRANK W. FINGER

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YOUR CHILD'S MIND AND BODY. *A Practical Guide for Parents.*

By Flanders Dunbar. Random House, New York. $2.95. xii + 324 pp. 1949.

Flanders Dunbar has written another comprehensive book relating psyche and soma. This time she energetically attacks the problem from the pediatric level. She has an enviable background as physician, mother, and pioneer in psychosomatic medicine upon which to draw for such a survey. With fine assurance she has produced a good book for parents to read—full of constructive illustrations, matter-of-fact descriptions, and definite directives.

The book is actually written *to* parents. Chapter headings are questions penetrating anxiety-laden areas for those who are bringing up children: Does Your

Child Sleep?; Does Your Child Eat?; Does Your Child Play?; Do You Love Your Child?; Does Your Child Obey?; Does Your Child's Body Obey Him?; Does Your Child Get Sick?; Does Your Child Commit Minor or Major Crimes? These broad questions just about cover everything, at least in the way the author treats them. After developing the theme of each chapter in terms of the youngster of pre-school or grammar school age, Dr. Dunbar appends a few words on "the Adolescent Aftermath" as a follow-up on a much neglected period of development. This is a very original and useful addition, greatly enhancing the value of the book as an aid to thoughtful parents whose children *do* grow out of childhood into adolescence, with all that period's special complications. *Your Child's Mind and Body* is written in a vivid, authoritative style. There can be no doubt that Flanders Dunbar knows her own mind and is convinced that she has ideas of real value for her audience. She does, too!

Helen Arthur

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Your Child Makes Sense. *A Guidebook for Parents.*
By Edith Buxbaum; foreword by Anna Freud. International Universities Press, New York. $3.25. xvi + 204 pp. 1949.

This is an excellent book on the psychology of childhood, from the dynamic orientation of psychoanalysis. Edith Buxbaum had her original training in Vienna with Anna Freud and has since had many years of child psychoanalysis. This makes her unusually well-qualified to write on a topic which has been subjected to so much undisciplined verbosity. Following an impressive foreword contributed by Anna Freud and a friendly introductory page or two by the author is chapter 1, contributed by Florence L. Swanson, on the Physical Development and Care of the Child. This sets the stage for the correlation that must be felt between the physical and psychic aspects of the growing individual.

From this point on Edith Buxbaum takes over, covering a number of important issues that parents should know about in order to be more successful parents. She discusses among other things the mother-child relationship, sex development, the child and his family, and the child and his school. These are, of course, the usual items, but in this volume they are treated in a new way, a much more valid and pragmatic way, from the point of view of what actually goes on in the child's emotional life. At the end there is a section entitled Related Reading to which an interested reader may turn for a recommended bibliography on child care and emotional development. This list alone makes the volume an important contribution to literature of this type.

Your Child Makes Sense is written specifically for non-professionals. The author spends no time on theory alone. She briefly states the psychiatric facts involved but relates them immediately to actual situations. She has an effortless, somewhat amorphous style that carries the reader along easily but not soporifically. Because of its non-technical approach, this book can be read by anyone. Because of its sound psychodynamic orientation to the common childhood problems, it should be read by all who question their child's behavior. This does not exclude psychiatrist parents, who are often in need of just such a down-to-earth, practical presentation of certain everyday issues.

Helen Arthur

* * *

The Psychoanalytic Reader. *An Anthology of Essential Papers with Critical Introductions.*
Edited by Robert Fliess. International Universities Press, New York. $7.50. 392 pp. + 1 chart. 1948.

This is a book of genuine importance to all students of psychoanalysis. Fliess has done a real service in compiling in one volume 27 important psychoanalytic papers, hitherto either very difficult to find or not even translated. He has devoted an immense amount of time, as well as professional discernment, to going through the psychoanalytic literature, sorting out repetitious, non-contributive papers, and finally selecting the basic articles included here.

In this book, the first of a contemplated series, Fliess has grouped the papers under five topic headings: Clinical; Theory; Miscellaneous; Uncollected Papers by Karl Abraham; and References by Freud. This last section is fascinating, for papers to which Freud has referred in his writing are quoted in full, along with the parts from Freud's own writings which contain the allusion. Because of the careful grouping of the papers, the exceptional quality of all of them, and the fact that all the authors are (or were at the time of writing) traditional Freudian psychoanalysts, the continuity and coherence of thought in the book is quite impressive. Not only the original authors, but also the editor, must be credited with excellent work. Future volumes will be awaited eagerly.

Helen Arthur

* * *

The Neurosis of Man. *An Introduction to a Science of Human Behaviour.*
By Trigant Burrow. Harcourt, Brace and Company, New York; Routledge and Kegan Paul, London. $7.50. xxvi + 428 pp. + 5 plates; text ill. 1949.

The general thesis of this book is that man as a species is the victim of a neurosis, due to the fact that his "third nervous system," that making possible symbolic function as contrasted with the visceral and sensory-motor functions of the other two, has tended to separate him from his environment and has thus induced a partial (partitive or ditentive) reactivity replacing the whole (cotentive) reactions which would otherwise take place. Out of this condition the author concludes that all the world's interrelational problems arise, and he posits that this "phylic" neurosis must be somehow cured before man can successfully escape the fate he appears to be making for himself with wars, atomic bombs, and the tendency toward strife in general.

It must be stated here that the above interpretation may well not be what the author intended to convey, since the book is written in a language the symbols of which are unusual and difficult in spite of their very frequent repetition. As a sample of the type of writing in which the ideas of this book are entombed, consider the following: "Accordingly, there is need to recognize that man's adaptation has come to be almost exclusively partitive, episodic, disjunctive. Dealing indiscriminately, as we now do, with the symbols or indices of objects and with the symbols or indices of one another, man has come to assume a projective basis of behavior that is wholly insular and discrete." (p. 169). It is unfair to pick a particular section—this is by no means the most exaggerated sample that could have been used—to characterize the language of a book. Nevertheless, the prospective reader should be warned.

The book pretends to be a report of experimental work and has an appendix giving some data on respiration, heart rate, basal metabolic rate, and oculomotor function in the various states of attention discussed by the author. For the most part it is, however, a rather confusing array of ideas. These ideas have relations with some familiar theses. One will find hints of a "back to nature" philosophy, of the control of thought and feeling through use of physiological function in a way reminiscent of Yogi cults, and a long dissertation on the differences between the author's philosophy and Korzybski's semantics. There is also an attempt to get at the biological implications of religion, to destroy the concepts of right and wrong, and to replace them with a concept of biological success and failure. Finally, there is an effort to show that if man were again to combine his symbolic functions, which are basically physiological, with the other recognized physiological functions, then all would be well.

One of the basic contentions in the book is that individuality is unsound and that it is nothing more than "face," also called "'I'-Persona." It is not unfair to point out that the author has face enough left after his study to explain how his name is pronounced and to tell a number of his personal experiences, neither of which additions contributes to his thesis. There are some stimulating ideas in the book, but the cost of sharing them with the author is very great.

PAUL V. LEMKAU

MODERN PRACTICE IN PSYCHOLOGICAL MEDICINE.

Edited by J. R. Rees. Paul B. Hoeber, Medical Book Department of Harper & Brothers, New York. $10.00. xii + 488 pp. 1949.

This textbook of psychiatry, intended for students of medicine and general practitioners, and written by a group of well-known British specialists, is a conservative statement of present thought concerning personality development and its deviations and treatment. It is conservative in the sense that it rests essentially on clinical observation, with a minimum of theory, which in fact serves no particular purpose in the actual handling of cases. Considering the statement in the foreword that attributes to Freud's contributions the great present day interest in things psychiatric, there is remarkably little about Freudian theory and research in the body of the text and in the references listed at the end of each chapter. There is no occasion to deny that this is a dynamic approach. It is such, but more in the traditional English sense, which follows the Meyerian tradition in this country. The several chapters dealing with personality development and the various forms of psychiatric deviation and treatment are very well presented, and this should be a good book for medical students and practitioners.

Only two contributions to the book come from America: one by D. Ewen Cameron, a Scot transplanted to this country, and one by Samuel W. Hamilton on the Medico-Legal Aspects of Psychiatry, as practiced in the United States. Cameron's chapter on Sexuality and the Sexual Disorders is factual, rests on common experience, and is remarkably devoid of esoteric theory.

WENDELL MUNCIE

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PROGRESS IN NEUROLOGY AND PSYCHIATRY. *An Annual Review. Volume IV.*

Edited by E. A. Spiegel. Grune & Stratton, New York. $10.00. xiv + 592 pp. 1949.

This excellent review of the most recent contributions in neurology and psychiatry has been ably presented by an imposing group of contributors and edited by E. A. Spiegel of Temple University. It is divided into four parts: The Basic Sciences, Neurology, Neurosurgery, and Psychiatry. Of the 582 pages of text, 178 are devoted to psychiatry. Nevertheless, throughout the neurological contributions one sees constantly the encroachment of psychological aspects as, for instance, in the chapters on the psychopathology of vision, the surgical treatment of pain and motor disorders, psychosurgery and the autonomic nervous system, and others. The psychiatric chapters are very well done indeed. These deal with clinical psychiatry, mental hygiene, forensic psychiatry, child psychiatry, neuroses, psychosomatic medicine, alcoholism, the Rorschach and other projective technics, shock therapy, group psychotherapy, psychiatric nursing and occupational therapy, psychoanalysis, rehabilitation and reeducation. The material is well digested and amply documented. Assuming that the part dealing with neurology is equally well done, this book should be a very valuable addition to the medical library and a time-saver in combing the literature for pertinent material.

WENDELL MUNCIE

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COMPULSION AND DOUBT. *(Zwang und Zweifel). Volumes I and II.*

By Wilhelm Stekel; authorized translation by Emil A. Gutheil. Liveright Publishing Corporation, New York. $7.50 for two volumes. (I) x + Pp. 1–323; (II) ix + Pp. 324–645. 1949.

In this two volume series, Stekel provides a very comprehensive treatment of the effects of anxiety, dread, and doubt upon human personality. He discusses in detail various forms of neurotic obsessions and compulsions, and attempts to demonstrate the hidden causes and subconscious motives involved in their development. The work is enlivened by the inclusion of approximately 80 case histories, many of which are presented in great detail. These case histories illustrate the effects upon personality and character of persistent compulsions and doubts. Typical chapters are devoted to criminal impulses, compulsions and masturbation, the incest complex, compulsion and impotence, homosexuality and patricide, and so on.

The over-all value of this work is difficult to estimate. It is apparent that Stekel is a disciple of Freud. Undoubtedly his interpretations of the case histories presented will appeal to all other analysts and psychiatrists who believe in the Freudian interpretation of personality. They will hail this new translation as a major contribution to the literature of psychoanalysis. Others, who deal with disordered personalities without benefit of Freudian doctrine, will be much less enthusiastic about the approach to the phenomena of compulsion and doubt taken in this book.

The present reviewer feels that the prevalence of anxiety, dread, doubt, compulsions, and obsessions among modern men makes it imperative that every clinician working in the field of personality disorders learn as much as he can about these phenomena. For this reason it is believed that these two volumes should be included in the professional library of every psychiatrist, psychoanalyst, and clinical psychologist. They would seem to have very little value elsewhere.

WENDELL W. CRUZE

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BASIC PRINCIPLES OF PSYCHOANALYSIS.

By A. A. Brill; with an introduction by Philip R. Lehrman. Doubleday & Company, Garden City, New York. $3.45. xviii + 298 pp. 1949.

This is Brill's last writing, edited after his death by his friend, Philip R. Lehrman. As in everything Brill ever wrote, one finds here a commendable clarity and a singleness of purpose which leave the reader with admiration for the author's very real literary as well as scientific abilities. The book covers all the well known material of any psychoanalytic textbook, the history of the method, the basic tenets, and the basic manifestations in everyday life and dreams. There are very valuable chapters on the functions and motives of dreams and their interpretation, the types of dreams, and common forms of psychoses. Then there are some additional final chapters of general interest concerning the only child, fairy tales and artistic productions, and the selection of vocations.

There is nothing a reviewer can say to add to Brill's stature. It is fitting that the man who introduced psychoanalysis into this country should leave such a readable, instructive textbook on the subject.

WENDELL MUNCIE

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SEXUAL BEHAVIOR: *Normal and Abnormal.*

By Eustace Chesser. Roy Publishers, New York. $3.75. xii + 295 pp. 1949.

The theme of this book is that sexual problems are usually personality problems, that personality adjustment is largely a function of the home in which the child has grown up, and that the most serious threat to this home is the mother's urge to be "emancipated." Chesser's first point is that the purely physical aspects of sex life have been overemphasized at the expense of the subtler emotional attitudinal aspects. Actually, they are inextricably interwoven, and tied in with the individual's whole pattern of habitual adjustment. Sexual deviations are much more often the result of emotional disturbances than their cause. Much of personality maladjustment can be traced to the long-standing cultural assumption (illustrated in the early Christian teachings) that woman is an inferior species and that sexual behavior is an unfortunate racial necessity. This leads to a certain amount of anxiety in nearly everyone, but in woman "the legacy of . . . confusion, resentment, fear, suspicion, and, above all, of shame" is so great that she quite understandably seizes the opportunities made possible by educational and economic changes to escape from the responsibilities of normal sexuality and maternity. This would not be particularly disastrous if some women rejected marriage altogether and the rest accepted it unconditionally. The critical problem centers around the large number who, unconsciously, reject the maternal role just enough to create in the home an air of discontent, uncertainty, and insecurity, which in turn distorts the whole personality (and hence the sex attitudes) of the next generation. Woman must be helped to understand that she is not the inferior of the male—she is in reality superior, "Nature's chosen sex." And at the same time sexuality must be accepted by all in its proper perspective, as a natural drive that can reinforce the optimal development of the whole person.

The "abnormal" in the title is stressed very little in the discussion. For the most part extreme deviations are described only to illustrate the *quantitative* relation between the abnormal and that range of behavior that is classed as normal, and to reassure those who feel themselves to be greatly different *in kind* from the average of the population.

The rationale of the section on psychosexual development is unmistakably Freudian. The usual objections to the untestable hypotheses will of course be raised in this connection, although the descriptions are couched in such common-sense language as to be quite disarming. Beyond the dependence on psychoanalytic formulations, the book is clearly all Chesser's. The virtual absence of references to recent research on sex attitudes and behavior (Kinsey's name being conspicuously missing) leads one to wonder if the breadth of the author's acquaintance is as limited in his special field as it appears to be in some of the supporting areas. Perhaps it is just as well that such mechanical implements as statistics are eschewed, for in the one instance when he attempts to play with figures, Chesser falls into complete confusion. The lack of an index reinforces the impression that the book is intended to be read as an essay rather than studied as an authoritative textbook or used as a handbook. Regarded in this light, many of the ideas in *Sexual Behavior* are well worth consideration.

FRANK W. FINGER

HUMAN BIOLOGY

TRÆN-FUNNENE. *Instituttet for Sammenlignende Kulturforskning. Serie B: Skrifter. XLI.*

By Gutorm Gjessing, with the assistance of Ole T. Grønlie, Oluf Kolsrud, and K. E. Schreiner. H. Aschehoug & Company (W. Nygaard), Oslo; Kegan, Paul, Trench, Trubner & Company, London; Otto Harrassowitz, Leipzig; Société d'Édition "Les Belles Lettres," Paris; Harvard University Press, Cambridge. N. kr. 35.00 (cloth); n. kr. 30.00 (paper). viii + 234 pp. + 52 plates; text ill. 1943.

The archeological finds at Træna, a rocky island located on the Norwegian Coast just below the Arctic Circle, are interesting, rich, and variegated. On the island are found not only prehistoric caves, but also houses and graves. Here have been found a great many artifacts of bone, flint, and stone, as well as weapons, tools, and jewelry of iron, bronze, and gold. The accumulation of pottery is not insignificant. Last but not least, there has been found here a rather unusual material of human skeletons. With an intermission of a couple of centuries (the Merovingian times to the late Middle Ages), the finds cover a period of thousands of years, from the Older Stone Age (Paleolithic) to the Late Middle Ages.

The report on the bulk of the finds is written by Gutorm Gjessing. Exceptions are: a chapter on the geology of the island (*Kvartærgeologiska undersökningar*) by Ole T. Grønlie; a chapter on a golden ring found there (*Gullringen*) by Oluf Kolsrud; and a chapter on the skeletons (*Skjeletterne*) by K. E. Schreiner.

According to Schreiner, the racial characteristics of the skeletons do not differ much from what is known about medieval skeletons in Oslo. In general, the race seems to be Nordic, with some deviations (brachycephalism) pointing to the Alpine race rather than to the Lapps. Of the 47 individuals, 19 must have died before they reached the age of 20 and only 5 reached the advanced age of 50, one of whom may have become 60.

The ring is dated by Kolsrud to the first half of the 15th century on paleographic grounds. It has a magic inscription (*bure, berto, beriora*) to stop bleeding, to which there are several 15th century parallels in Scandinavia and elsewhere.

According to Gjessing the archeological material (skeletons, tools, pottery, etc.) was found both inside and outside the caves, of which *Kirkehelleren* (the Church Cave) was the most imposing, though not the largest.

Immediately south of that cave, in a bog, there were found ruins of old houses and a sort of a causeway of stones, leading over the bog to a place ca. 23 meters above the present sea-level. The archeologists decided that when this causeway was built, it led, indeed, down to the then existing sea-level (ca. 22 meters), and thus dated the path to the Older Stone Age (Paleolithic). Investigation of the ruins corroborated this: the artifacts, and probably also the house ruins themselves, date from Paleolithic times (more specifically from what the Scandinavian archeologists call Nöstvet-time). If so, these are the oldest known houses in Scandinavia, which makes the find important indeed. Of other results one may mention Gjessings' finding that the culture of the Stone Age remained much intact until the advent of the Iron Age.

There is no possibility of going into the rich detail of the book. It is a pity that the authors themselves did not give their results in short English résumés, for their finds seem to be quite important. Nevertheless, those who are really interested, geologists, archeologists, and anthropologists, can probably find their way around in the rich material of the Plates (52 in number) at the end of the book.

STEFÁN EINARSSON

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PREHISTORIC POTTERY AND CIVILIZATION IN EGYPT. *The Bollingen Series VIII. Pantheon Books.*

By Max Raphael; translated by Norbert Guterman. Bollingen Foundation, Washington, D. C. $7.50. 160 pp. + 36 plates. 1947.

This strictly archeological treatment of the prehistoric pottery of Egypt resembles the author's previous contribution to this series, *Prehistoric Cave Paintings* (see Q.R.B. 21: 125. 1946), in elaborating the meaning of the ornamentation in terms of cults, in this instance the cult of the dead and the rites of magic. The style adopted by the author is simpler, however, and the interpretations are more direct and readily followed. The plates are outstanding.

BENTLEY GLASS

◆

THE WOLF AND THE RAVEN.

By Viola E. Garfield and Linn A. Forrest. University of Washington Press, Seattle. $3.00. x + 151 pp.; ill. 1948.

The carving of totem poles is an art which was practiced very locally by the Indians of the Pacific Northwest, notably those of the Tlingit tribe. It is now largely a lost art, even though some of the poles were made as late as 1905. Modern philosophy, which came with the white race, has disrupted the nature culture with its strict adherence to maternal lineage, and the race myths and lineages which are symbolized in the elaborate carvings are remembered only by the older tribal members.

Recognizing that the wooden poles were in danger of extinction through decay, weathering, and pilfering, the U. S. Forest Service in 1938 began a systematic collection and restoration of totem poles, which were localized for the benefit of visitors and with the consent of the Tlingits. Parks at Saxman, Ketchikan, Mud Bight Village, and Klawak, in southeastern Alaska now contain the best of the remaining poles, through a project carried out by the junior author. Garfield, an anthropologist, has collected the legends, histories, and lineages which the poles symbolize. Each totem is discussed individually and each is illustrated by photographic reproductions. The total effort has resulted in a fascinating story of an Indian group which sought expression in a unique and spectacular manner. It is unfortunate that the half-tone illustrations do not provide the sharpness of detail and the color which the text deserves. When it is considered that the totem poles represent a form of art peculiar to a region of America and in its last stages of existence, one is led to wonder why nothing was done to preserve it before 1938.

C. P. SWANSON

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CHINA: THE LAND AND THE PEOPLE.

Issued in Cooperation With The American Institute of Pacific Relations. By Gerald F. Winfield. William Sloane Associates, New York. $5.00. x+ 437 pp. + 16 plates. 1948.

This is by far the best general account of China's problems now available. The author, a biologist of many years' experience in China in the field of public health, has not limited himself to an analysis of that aspect of China's needs, but has produced a remarkably well-integrated study of the interrelationships of the land's geographic and human characteristics, the agriculture, diet, clothing, and shelter of the people, their commerce, industry, and transportation, health, education, language, local government, and the far-reaching consequences of war.

It is the second part of the book, entitled Rebuilding China, that is most thought-provoking. A statement of needs and goals leads to a consideration, first of all, of sanitation, China's most gigantic health problem. "The annual toll of death from fecal-borne diseases is as high as four million—one-fourth the total number of deaths from all causes each year." Hookworms, flukes, and astronomical numbers of ascarids (from 5 per person in 35 per cent of the population in urban dwellers of the north, to 35 per person in 98 per cent of the population in the rural rice-growing areas) deplete the vitality and resistance of the people. But the prevalence of such fecal-borne diseases and parasites is the inevitable outcome of the dependence of the farming population on human excreta to replenish the nitrogen of their fields. ("It is interesting to note that the amount of nitrogen present in the feces cakes is in direct ratio to the richness of diet of the people producing the night soil.") No effort to eliminate these conditions can succeed until some cheap and effective way can be worked out to sterilize the human fecal materials before they are used on the fields or fed to the pigs. This can be done, as the author has shown experimentally at Cheeloo University in Shantung, by composting the excreta in mixtures of 20 per cent night soil, 50 per cent animal manure, 20 per cent vegetable wastes (such as wheat straw, leaves, or dry grass), and 10 per cent field soil. This sounds simple to do, but anyone who knows China will at once see the difficulty. The plant wastes are universally used by the farm populations as the principal supply of fuel, wood for such purposes being extremely scarce. Hence, to solve the sanitation problem in the way proven to be feasible will require first a new source of fuel for the Chinese people. A great dam across the Yangtze River in the gorges above Ichang *could* supply over 10,000,000 kilowatts (3 times the generating power of the Grand Coulee, Hoover, and Shasta dams combined) and has been planned; but even this supply of power would have to be supplemented by a vast increase in the amount of coal mined. Fortunately, China has tremendous supplies of coal; but these will be of little value unless mining is modernized and the transportation facilities of the land are improved to enable the coal to be taken where it is needed.

Therefore a vast increase in China's railroad mileage is a necessity.

In another phase of the analysis, it is made clear that China's agricultural production, and hence her basic living standard, cannot be improved unless the average size of farms is increased from about 4 to about 13 acres apiece. The larger farms could then be worked by more modern methods and equipment, with a higher productivity per worker. This, however, would mean moving 180,000,000 persons off the land, and that of course cannot be done except they be absorbed in a great expansion of industry and personal services.

All of these steps, so intimately tied together, will be rendered futile unless the nation learns to control her population growth. The chapter on Population Control is the first really constructive proposal along these lines the reviewer, for one, has ever seen. The problem is faced with real courage. Gerald Winfield proposes that efforts to save life by combatting infectious diseases be held in abeyance until by a combined program of obstetrical and pediatric care, the plain people can be shown that it is not necessary or desirable for them to have so many births, and come to welcome methods of birth control. *Only when the birth rate has begun to drop will it be safe to undertake measures to reduce the death rate.* This sounds harsh to humanitarian ears, but one may well ask why one should save a person from death by disease merely to allow him to starve.

These questions culminate in the need for education, which must be the prime mover if such interlocked problems are to be attacked with intelligence and wisdom. The final chapter brings in the fateful theme of political domination. With all its faults, the Kuomintang held out more hope for China to realize these goals than the Communists can possibly manage to do. This book is a superlative analysis that shows what might have been. It should be read by every thinking American, in spite of the mental depression that will follow.

BENTLEY GLASS

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GIPSIES IN DENMARK. *A Social-Biological Study. Opera Ex Domo Biologiae Hereditariae Humanae Universitatis Hafniensis. Volume 5.*

By Erik D. Bartels and Gudrun Brun. Einar Munksgaard, Copenhagen. Kr. 12.– (paper). 180 pp. + 3 plates. 1943.

This excellent study of nine gipsy families in Denmark should serve as a future model of a genetic-social investigation carried out without the influence of national politics. The authors were asked by the public aid authorities of the City of Copenhagen to study the gipsy families and to determine as far as possible the parts played by heredity versus environment in determining the peculiarities of gipsy behavior.

The history of gipsies outside Scandinavia until about the year 1900 is traced in the second chapter. Language studies in 1775 revealed the original home of gipsies to be India. They were brought into Persia to serve as court musicians in the fifth century A. D. Gipsies wandered to Greece, the Balkans, and on up into Europe during the middle ages. Numerous unsuccessful attempts were made to colonize them. In centuries gone by, as is usually the case in present times, they earned what livelihood they could by serving as musicians, in circuses, as tinkers, horse traders, and dealers in handicrafts. Through a strict system of intermarriage, the language and customs of the gipsy tribes have been maintained for centuries. However, in recent times, admixture with settled groups, usually of a rather low social order, has taken place to a large degree, and has resulted in a mixed population.

Chapter III deals with a history of the problem of vagrants, aside from gipsies, with especial reference to Danish conditions. During the Middle Ages beggars, wandering friars, peddlers, ex-soldiers, and artisans were constantly on the road. A class of regular vagrants arose in Denmark, probably from executioner's men, ex-soldiers, and their women. This group, called "nightmen," earned a living scavenging in the towns, removing the carcasses of animals dead from accident or disease, gelding horses and boars, and chimney-sweeping. This group has now been successfully absorbed into honest, settled populations in Denmark, with apparently no ill effects upon the latter.

In Chapter IV the history of gipsies in Scandinavia is traced. The exact time of entry of gipsies into Denmark is not known, but in 1512 a royal decree was issued banishing them. Stringent gipsy laws from the sixteenth to the eighteenth centuries in Denmark reveal a merciless persecution of this unfortunate group.

Chapter V is entitled "Gipsies in Our Days. What is Meant by a Gipsy?" and reviews an extensive investigation of gipsies in Germany by Ritter (1937). Unfortunately, this work seems hopelessly influenced by the theories of National Socialism regarding racial superiority and inferiority. Bartels and Brun view this work with somewhat more sympathy, but do take a firm stand against Ritter's claim that with an increase of gipsy blood, mixed gipsy children become more dark in hue and pari possu their intellect becomes more and more deficient. The German outlook on gipsies is exceedingly pessimistic, and upon mixed gipsies is even more gloomy. Ritter's latest work has indicated that the Germans were contemplating sterilization measures against gipsies. Ritter's own definition of a gipsy is an individual who has among his grandparents at least three gipsies. A mixed gipsy, then, is an individual who had among his grandparents either one or two pure gipsies or at least two quarter or half gipsies. The Danish authors make use of these definitions in their study.

In Chapter VI the history and mode of living of modern Danish gipsies is discussed. The nine families which form the object of this study emigrated from the northern part of Germany, mostly from Schleswig and Holstein, between 1800 and 1850. Their mode of living resembles that of their ancestors. Their occupations include the fair business, running merry-go-rounds or swing boats. Some are artistes, a few being at the top of their professions in circuses; some own circuses; others are street musicians, or vendors of things of their own making such as paper flowers. Another principal occupation is grinding, and minor mending. Danish Sanitary Laws allow traveling about in caravan wagons only in the summer months. Consequently a permanent winter establishment is maintained by many of the Danish gipsies.

Chapter VII summarizes the relations of the Danish gipsies to the public relief administration, and also to criminality. A great deal of public relief is expended upon the gipsies. On the other hand, their contacts with the police are usually only the consequence of petty offenses. Not a single serious crime has been committed by any member of the nine families of modern Danish gipsies.

Chapter VIII discusses the racial composition of modern Danish gipsies. As the authors point out, their nine families, traced for six generations, now contain few pure gipsies. Most individuals are "mixed gipsies," and the entire group of from 700 to 800 persons will in time (estimated at 50 to 100 years) become assimilated into the native Danish population. The next chapter contains pedigrees and a detailed history of eight of the nine families studied. Such a detailed study could not be made of the ninth family, but it was known to resemble the others. These reports were made up not only from public aid records and school records, but also from careful visits to the homes and caravan wagons of the gipsies and long conversations with members of the family and with their neighbors. Far from being influenced by the pessimistic outlook on the gipsy problem taken by Norwegian and German authors, the Danish authors have preserved a true scientific impartiality in their investigations.

In the final chapter, the authors conclude that gipsies in Denmark do represent a "biologically delimited group within the population" because of (1) their foreign appearance (i.e., dark complexion, characteristic features), (2) their own feeling of being an entity separate from the native Danish population. Secondly, the authors believe Danish gipsies to be in general mentally sound. Bartels and Brun take exception to the views of Ritter that even mixed German gipsy populations possess a "special form of feeble-mindedness." The Danish authors state that the cultural background of the gipsy in general affects him in such a way that he completely lacks the inclination to adapt himself to a normal, settled, orderly existence. Thus he neither likes to stay long in one place nor to have permanent work. No great criminality exists among the Danish gipsies, though they are often guilty of small offenses because of their poverty and lack of education. The authors suggest that the peaceful and kindly conditions in Denmark may have some bearing on the low criminality among Danish gipsies, compared with the high number of criminal offenses found among them in Germany. The authors believe that it is not possible to change the Danish gipsies' way of life among those now living. They observe that the Danish gipsies are rapidly becoming assimilated into the native population, and state that "although the gipsy families cost the community a considerable sum of money," they are "no danger to public security." The authors are firmly opposed to Ritter's advocacy of sterilization of all individuals displaying asocial behavior. From the point of view of eugenics, Bartels and Brun point out that the gipsy families have shown that they are capable of fostering citizens who are just as good as the the average of the population. They suggest that gipsies in their capacity as entertainers and owners of circuses have performed a service to small isolated villages.

The reviewer is impressed with the spirit of kindliness and scientific honesty with which this investigation has been carried out at a time when Denmark was occupied by the Germans. The study of Danish gipsies is thorough to the smallest detail. Upon reading the case histories, one feels the greatest admiration for the complicated system of Public Aid which one learns must exist in Denmark. Such a system, carried out with patience, is designed for helping the indigent individual to help himself. Excellent photographs of various Danish gipsies are included at the end of the monograph. The monograph is written in practically faultless English.

SARAH BEDICHEK PIPKIN

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MALE AND FEMALE. *A Study of the Sexes in a Changing World.*

By Margaret Mead. William Morrow & Company, New York. $5.00. xii + 477 pp. 1949.

The author has tried to find out what the differences between the two sexes actually are, in order to build a better society on such knowledge. She here confirms her earlier findings that most of these differences are social conventions, built up in childhood, a developmental stage to which she has always attributed an exclusive importance for character formation. Miss Mead goes again over the seven South Sea cultures she has observed, and in examining the formation of males and females there she has discovered, besides the well known anal, oral, and other types of sex behavior delineated by Sigmund Freud, a new one, the womb envy of males. The basic thing in females is their ability to bear children, while men, according to the author, are eternally uncertain of their ability to perform sexually and of their fatherhood, which makes them more aggressive, active, etc. The author also makes some comments on the relations of sexes among the people of the United States, the difficulties of bringing up girls like boys and then making housewives of them, etc.

This book will be a disappointment to those who have liked the author's earlier monographs, which were indeed always subjective, but also lively and stimulating. These 500 pages of very involved writing seem to lead nowhere but to the few not very helpful generalities mentioned above. It might be suggested that this sad result has something to do with Margaret Mead's particular anthropological methods, which she explains, lauds, and defends at great length. They seem not to be very adequate in reaching valid theoretical and practical generalizations, especially when applied to the more complex non-tribal societies.

Erwin H. Ackerknecht

* * *

From Cave Painting to Comic Strip.
By Lancelot Hogben. Chanticleer Press, New York. $5.00. 287 pp.; ill. 1949.

If man is unique, concludes the author, it is because he is "the only picture-making animal which has ever lived on our planet." Nothing else about him is more than an extension of features found in other animals. With copious and excellent illustrations, the pictorial strand is followed from some 30,000 years ago to the present day. Careful consideration is given to the relationships of totemistic signs, zodiacal portents in relation to agriculture, alphabets and modes of counting, paper-making, playing cards, and movable type. Hogben traces the shift of centers of civilization northward and shows how cloudy weather plus winter cold make understandable the new interest in the technology of glass-making—and its products, such as clear window glass, lenses, and eyeglasses. He points to the standardization of spelling and grammar which followed the introduction of printing, and to the development of the international symbolisms that have grown up in electronic circuit representations, in floral diagrams, and atomic detail. As a culmination in this direction, Hogben praises at length the universal picture language begun by Otto Neurath in 1925 in Vienna, and called "Isotype";—the present "book is a tribute to his memory." Printers' ink, vanishing points, map making, color printing, and improvements in press design bring the subject to modern times and a carefully documented analysis of the American comic strip, with the frustrations of everyday life found to be the clue to its appeal. The book ends with a plea for early adoption of an international language and for an acceleration in the training of world citizens through wall charts, motion pictures of improved types, and other visual aids—with emphasis on such universally understood symbolism as Neurath's Isotype.

The book is handsomely presented, but the choice of Monotype Poliphilus, with its slanted hyphens and stylized numerals, makes for slower reading. On a page with phonetic symbols a Poliphilus 5 is not identified as easily as a familiar 5. The captions for the illustrations, in many instances, are confusing in their departure from the conventional sequence, the reader being guided first to the figure in the lower corner of the right-hand page, then to the lower left, then the upper right, next middle left, and so on. In a book subtitled, as this one, "A Kaleidoscope of Human Communication," with such excellent illustrations of the best of cave drawings and of modern color photography, it seems that a more valiant effort might have been made to use the best of type faces and a more customary sequence in the captions.

Lorus J. & Margery J. Milne

BIOMETRY

Introduction to the Theory of Probability and Statistics. *Wiley Applied Mathematics Series.*
By Niels Arley and K. Rander Buch. Edited by I. S. Sokolnikoff. John Wiley & Sons, Inc., New York; Chapman and Hall, Limited, London. $4.00. xii + 236 pp. 1949.

This, the second book in Wiley's newly-created Applied Mathematics Series, is a translation of the third edition of a Danish text. The senior author is an assistant professor of physics in the Institute for Theoretical Physics at the University of Copenhagen, the junior author an assistant professor of mathematics in the Institute for Applied Mathematics at the Denmark Institute of Technology. According to the authors, the purpose of the book is to provide an elementary introduction to the theory of probability and statistics, with special emphasis on practical applications. It appears to have been aimed at a broad audience including students in physics, biology, engineering, and other sciences. Examples are selected from such diverse fields as ordnance, telephony, theoretical physics, and actuarial science.

American students in biology will find this a high-level textbook despite the word "Introduction" in the title. In order to understand all beyond the first three chapters, the student should have a background in calculus, linear equations, and the theory of matrices. One feature of the book which, in the reviewer's opinion, makes it thoroughly unsuited for an English audience is the entirely new system of symbols and notations the authors introduce. English-speaking statisticians and biometricians have long deplored the lack of any consistent system of notation in the field. This, more than anything else, is a source of serious annoyance and confusion for the student. At least certain terms however, seem to have been reasonably well standardized in most English and American texts. Among these are r (the correlation coefficient), p (probability that an event will happen), q (1-p), and F (the ratio between variances). Variants of other symbols, not so well agreed upon (for degrees of freedom, mean, and variance, for example), are at least familiar to many students of statistics. All these familiar cues are lost in this book. The almost universal F is replaced by w^2, r has become ρ, p has become θ, degrees of freedom are symbolized by f, and so on. In fact, a student trained on this book alone would almost certainly not be able to understand the statistical terminology used in current scientific literature.

A. CHAPANIS

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ANALYSIS AND DESIGN OF EXPERIMENTS. *Analysis of Variance and Analysis of Variance Designs.*

By H. B. Mann. Dover Publications, Inc., New York. $2.95. x + 198 pp. 1949.

This book—one of the Dover Series in Mathematics and Physics—is about the analysis of variance and the analysis of variance designs as statistical procedures. The contents provide a complete, although brief, coverage of the field. Starting with the chi-square and F distribution functions, the textbook then discusses the analysis of variance in one-way and *r*-way classifications, Latin squares, orthogonal Latin squares, incomplete balanced block designs, factorial designs, randomized designs, the analysis of covariance, and many other topics.

This is a book by a mathematician (the author is Professor of Mathematics at the Ohio State University) written for mathematicians. Its goal is to provide a rigorous mathematical treatment of the subject. The author has gone far toward achieving this objective but, in so doing, he has written a book far beyond the practical experimenter. The discussion is entirely at symbolic level, with no illustrative examples, problems, or guides to computational procedures. In short, this text is for professional statisticians and mathematicians. The biological scientist had best look elsewhere for help on analysis of variance designs.

A. CHAPANIS

DE OMNIBUS REBUS ET QUIBUSDAM ALIIS

GIANT BRAINS.

By Edmund Callis Berkeley. John Wiley & Sons, Inc., New York (Chapman & Hall, Limited, London). $4.00. xi + 270 pp. 1949.

Surely everyone has by now read in newspapers and magazines about fabulous computing machines which are so fast and so complex that they stagger the imagination. Not only do these machines perform extraordinary feats of calculation (the ENIAC, for example, can do 5000 additions a second), but they also make decisions, choose between different courses of action, learn, remember, and determine most of their own instructions. These machines are the subject of *Giant Brains.*

The author starts with the query, Can Machines Think? and in the first chapter he compares, point by point, the characteristics of human thinking with the kinds of operations mechanical brains can perform. The second chapter considers and classifies various systems for handling information. Chapter 3 shows in detail the principles on which a simple mechanical brain can be constructed. The next six chapters describe several existing large-scale mechanical computers, including a "thinking" machine called the Kalin-Burkhart Logical-Truth Calculator. The final three chapters look to the future, speculating about machines now in the design stage and the effects that they will have on our future society.

If you have any curiosity at all about these gadgets, you will find this a fascinating book. It is written by an expert in the field and so is authoritative. This last sentence, however, should not frighten the reader because this book is a model of what can be done to make difficult material comprehensible. It is excellently written and even if you understand little or no mathematics, you will find here much to excite your interest.

A. CHAPANIS

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FORGOTTEN MYSTERIES.

By R. DeWitt Miller. Cloud, Chicago. $2.50. xiv + 202 pp. 1947.

The mysterious and the inexplicable have always been intriguing, even when accompanied by distrust, apprehension, or muttered prayer. They also serve, to some, as a reminder that science is not infallible and all-knowing, and that the embracing arm of faith is comforting indeed when footsteps sound on the stairs, or the phantom barkeep puts in his appearance. The author has gathered together these tales for the curious, the scoffers, or the believers, and with no other intent except to say "Here they are; make of them what you will." Included are the poltergeists, phantom armies, deserted ships, and sea serpents, to mention a few of the varied mysteries. The book was published too early to include the flying saucers of recent days. Many of the tales are well documented. Some undoubtedly lend themselves to psychological explanation, others to no logical solution. All make interesting tales for a dark and rainy night.

C. P. SWANSON

NO PLACE TO HIDE.
By David Bradley. An Atlantic Monthly Press Book, Little, Brown and Company, Boston. $2.00. xviii + 182 pp. 1949.

BOMBS AT BIKINI. *The Official Report of Operation Crossroads.*
By W. A. Shurcliff. Wm. H. Wise & Company, New York. $3.50. x + 212 pp. + 33 plates. 1947.

Between them, these two books give a clear picture of the Bikini tests of the atomic bomb in 1946. Bradley's book conveys the vivid impressions and the psychological impact of the events on an observer. The official report, however, gives far more detailed and precise information about the tests, including the effects upon exposed animals and plants. (The study of genetic effects is barely mentioned, however, and is limited to mice alone, although the report on hereditary effects induced in maize seeds has by now been reported in *Genetics*, 34: 639–646. 1949.) Somehow—for a scientist, at any rate—the implications of the bomb for the future of human civilization strike one more forcefully in reading the simply stated facts of the official report than in all of Bradley's vivid narrative.

BENTLEY GLASS

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ELECTRON MICROSCOPY: *Technique and Applications.*
By Ralph W. G. Wyckoff. Interscience Publishers, New York and London. $5.00. x + 248 pp.; ill. 1949.

In comparison with the optical microscope, the electron microscope provides an extension of sight into the invisible world comparable to that which the optical microscope gave to the unaided eye. Refined techniques can now resolve particles less than 20 Å in diameter. Since the author has been actively engaged in perfecting techniques which have extended the usefulness of electron microscopy, and since he has contributed, in prior years, to the development of radiation biology in general, he is well suited for the task of assembling a textbook which deals with the techniques and applications of the instrument. Microbiologists in particular will find ample material related to their studies. The chapters are well supplied with references. Wyckoff does not confine himself to biological subjects, however, for the application of the microscope to metallurgy and chemistry is fully covered.

Biologists will find the last four chapters (7–10) of particular interest, inasmuch as they deal with the electron microscopy of bacteria, viruses, and macromolecules such as hemocyanin, globulin, cellulose, collagen, and the like. The photographs are exceptional in their clarity. The earlier chapters cover the historical development and the physics of the instrument, together with the techniques used in the preparation of specimens.

As the author has emphasized, the full potentialities of the electron microscope have not yet been realized. This is understandable when one considers that its first use dates from 1931, and that several centuries of work have gone into the development of the optical microscope. Science, however, was better prepared to exploit the usefulness of the electron microscope, and the text conveys the considerable information which its use has brought forth. It is to be hoped that the x-ray microscope, not yet perfected, will prove as flexible and as adaptable a tool.

C. P. SWANSON

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PROCEEDINGS OF THE AMERICAN PHILOSOPHICAL SOCIETY *Held at Philadelphia for Promoting Useful Knowledge. Volume 92, Number 4.*
The American Philosophical Society, Philadelphia. $1.00 (paper). ii + Pp. 211–323; ill. 1948.

This number contains 7 papers on the Relation between International Affairs and the Traditional American Scene, presented at the Annual General Meeting April 22–23, 1948. In addition, it includes the annual R. A. F. Penrose, Jr. Lecture, on this occasion given by Robert B. Warren and entitled An Attempt at Perspective. Five other papers, on various topics, include the following 3 of biological interest: The Prehistoric Archaeology of Tangier Zone, Morocco (Hugh Hencken); An Unfamiliar Mechanism of Disease Transmission (Richard E. Shope); The Mechanism of Wounding by High Velocity Missiles (E. Newton Harvey).

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SCIENCE NEWS—12, 13, 14.
Edited by J. L. Crammer. Penguin Books, Harmondsworth, Middlesex. 1s. 6d. each (paper). (12) 160 pp. + 16 plates; text ill.; (13) 162 pp. + 10 plates; text ill.; (14) 160 pp. + 16 plates; text ill. 1949.

Among the articles in these three issues of *Science News*, the following are biological in nature: (12): The Light of Glow-Worms and Fire-Flies (V. B. Wigglesworth); Infectious Diseases and the Country Doctor (W. N. Pickles); Agene and your Bread; Viruses (K. M. Smith); Farming Front (R. N. Higinbotham); Micro-climates (Amyan Macfadyen). (13): Chromatography (E. Lester Smith); The Problem of Cancer (E. C. Dodds); Ancient Peoples of the Andes (G. H. S. Bushnell); Experimental Embryology Today (Michael Abercrombie); Population Problems of India and Pakistan (S. Chandrasekhar); Chloromycetin; Analysis of Psychological Fields (John Cohen). (14): The Discovery of the Bacteriophage (F. W. Twort); The Bacteriophage (Felix d'Herelle); The Nature of the Bacteriophage (Ralph W. G. Wyckoff); Viruses and the Veterinary Surgeon (G. P. West); Molecular Architecture in Plants (R. D. Preston); The Electrical

Activity of the Human Brain (William A. Cobb); Synthetic Fibres (R. W. Moncrieff). Number 13 includes, for the first time in the series, a number of fine color plates, illustrating the article on chromatography. In Number 14, the plates have been changed from rotogravure to half-tone engravings, printed on excellent paper. The historical series on the bacteriophage is particularly noteworthy. In all respects this little popular journal of science is proving its worth and improving its content.

Bentley Glass

Carnegie Institution of Washington Year Book Number 47, July 1, 1947–June 30, 1948. *With Administrative Reports Through December 10, 1948.*

Carnegie Institution of Washington, Washington, D. C. $1.00 (paper); $1.50 (cloth). xxxvi + 235 pp. + 5 plates; text ill. 1948.

In the current *Year Book* summaries and advance reports of work of a biological nature are those from the Division of Plant Biology, the Departments of Embryology and Genetics, and the Special Project of Ross G. Harrison. In the first of these, besides the continuation of the work on the photochemical activity of isolated chloroplasts, chlorophyll formation, and the occurrence and properties of chloroplast pigments, a very interesting report on the alga *Chlorella* as a source of food has been added. Genetic analysis of climatic races of *Potentilla glandulosa* and of the results of the selection experiment carried on at 3 transplant stations at different altitudes since 1938 represents a continuation of highly significant work in plant ecological evolution. Ralph W. Chaney has reported his interesting study of a living species of *Metasequoia* found to be living in China, although the genus was supposed to have been extinct since the Miocene.

At the Department of Embryology studies have been carried on upon: the length of the period in pregnancy during which the corpus luteum is necessary (Corner); the development of accessory reproductive organs in hamsters (Faith W. Lavelle); migration of the human germ cells (Witschi); development of the human testis and ovary (Gillman); development of the diaphragm (Wells); development of the vertebrae (Sensenig); development of the cranial arteries (Padget); the mammary gland of the monkey (Speert); spiral arteries in the human ovary (Reynolds); growth of the pregnant uterus in the rat (Bradin); structure of the uterus in relation to menstruation (Kaiser); physiology of endometrial grafts (Kaiser); physiology of the uterus and development of a tokodynamometer (Reynolds); effects of anti-histaminics on the uterus (Reynolds & Kaiser); the source of fetal iron (Flexner); permeability of the the human placenta to sodium (Flexner et al.); and the physiology of the eye (Flexner et al.). The contribution to the achievements of the Department of Embryology made by guests and outside collaborators has been very considerable and marks the widening influence of this group of biologists.

At the Department of Genetics, Kaufmann has made further studies of the action of purified ribonuclease and pepsin on chromosomes, and also chemical studies of amphibian nuclei. Work on the genetic effects of infrared radiation and on the non-homologous associations of salivary gland chromosomes of *Drosophila* has been continued. McClintock's investigations of the effects in maize of a specific activator locus, which causes various loci in the short arm of chromosome 9 to become unstable, have led to new and quite startling genetic concepts. The high mutability appears to be due to a gain by one chromatid of something lost by its sister chromatid, bringing about an increase and decrease, respectively, of identical genetic units present in a reduplicated state within a locus. Demerec and his coworkers have continued their extensive investigations of the mutagenic potency of carcinogens and related compounds, of the chemical induction of mutations in bacteria, and of population dynamics in bacteria. Doermann has contributed a highly important study of the intracellular growth of bacteriophage, using sonic vibrations to disrupt the bacteria at various stages after their infection with phage. Caspari and Richards have studied the action of the gene *a* in *Ephestia* on tryptophane metabolism, and have also analysed a case of pseudoalleles in the mouse. MacDowell and his group have now freed the line of mouse leukemia they have studied from all the associated virus, and consequently have been able to analyse the effects of virus and leukemia separately and in combination. Dobzhansky has confirmed the existence of adaptive polymorphism in *Drosophila pseudoobscura* dependent upon upon different inversions which within populations become coadapted through natural selection, although the same inversions from different populations show no coadaptation. Harrison has summarized his studies on the origin, development, and growth of the forelimb in *Amblystoma*. In the development of the limb, the mesoderm plays the dominant role and the ectoderm a very subsidiary one.

Bentley Glass

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NUTRITION AND PHYLOGENY IN THE WATER MOLDS

By EDWARD C. CANTINO

Botanical Laboratory, University of Pennsylvania

(At present: Guggenheim Fellow at the Microbiology Laboratory, University of Delft, Holland, 1950–51.)

THE water molds are usually considered the most primitive of the true fungi and are generally found on plant and animal substrata in aquatic or semi-aquatic environments. In the following review, an attempt has been made to gather together and evaluate the significant contributions to our knowledge of their nutrition and metabolism. By integrating the data into an ordered whole, it has been possible to consider the bearing of nutritional criteria on some aspects of the phylogenetic relationships of the water molds.

NUTRITION AND METABOLISM

The following is a brief résumé of the results of nutritional investigations of the water molds. The Chytridiales, which to date appear to be completely autotrophic for all essential vitamins (Ajello, 1948; Quantz, 1943; Stanier, 1942; Whiffen 1941) may be segregated into two groups. The first includes species which can use one or more of the three substances chitin, cellulose, or keratin as sources of carbon (Haskins, 1939; Karling, 1945, 1946, 1947; and others). The most extensive investigations, however, have been made with those chytrids capable of decomposing cellulose. The ability to utilize other carbohydrates is limited more or less to cellobiose and glucose, the constituent sugars of cellulose, although xylose, mannose, and others may support some growth. Although it has been found (Quantz, 1943; Whiffen, 1941) that some of these fungi prefer inorganic nitrogen such as nitrate- or ammonium-N, Stanier (1942), working with *Rhizophlyctis*, determined that nitrate alone would not furnish this essential element. *Polychytrium* (Ajello, 1948), which can decompose both chitin and keratin, can utilize no carbohydrates other than glucose and starch. Furthermore, although organic-N is preferred to inorganic, nitrate and ammonium salts do support some growth. The second category includes fungi (Whiffen, 1941) which are not capable of decomposing cellulose and which lack the ability to grow on inorganic-N alone.

The nutrition of the Blastocladiales, which appears to be highly specialized, has also been investigated by Cantino (1948, 1949), Emerson and Cantino (1948), Leonian and Lilly (1938) Quantz (1943), and Stuben (1939). Here it would be wise to consider one group containing *Allomyces* and *Blastocladiella*, and the other containing *Blastocladia*. Quantz found that both *Allomyces* and *Blastocladiella* lack the ability to synthesize thiamine. Leonian and Lilly reported that *Allomyces* does not grow on a mineral-dextrose medium containing ammonium nitrate, thiamine, and amino acids. This, however, did not demonstrate conclusively whether or not the fungus is heterotrophic or autotrophic for thiamine. Although Ronsdorf (1935) found that a "bios" solution promoted growth of *Allomyces*, no definite conclusions can be drawn since several vitamins were probably present. That biotin is probably not necessary for growth is clear from Quantz's work and unpublished results of the author on two strains of this fungus. Quantz indicated that various sugars, such as glucose, fructose, maltose, and others, yield an increase in growth over that obtained on a basal medium without these sugars. Wolf and Shoup (1943), however, in studying the effects of carbohydrates on the respiration of four species of *Allomyces*, came to the conclusion that only dextrin (and for a single species, sucrose and maltose also) is respired. Since it is unlikely that a fungus which respires dextrin cannot respire glucose, these results do not present a serious objection to Quantz's observations. Finally, it is probable that nitrate cannot be reduced by these organisms, and that nitrogen must be supplied in the form of amino acids or other organic nitrogen compounds (although ammonium-N may be metabolized by *Allomyces*; cf. Quantz). On the other hand, the studies by Cantino have shown that *Blastocladia* is heterotrophic for three essential vitamins, namely, nicotinamide, thiamine, and biotin. *Blastocladia* can use a greater variety of sugars for growth than can the other two genera. Nitrogen must be supplied in the form of amino acids, and methionine seems to be an essential source of sulfur. This may well represent an exception to current concepts that, so far as is known, no fungus has a natural absolute requirement for a specific amino acid. Indeed this should not be surprising in view of established requirements of this kind for the lactic acid bacteria.

As yet, nothing can be said about the nutritional requirements of the Monoblepharidales. The flagellation of the zoospores offers evidence that they are closely related to the Blastocladiales, but there are no physiological data which can be used to support or refute this point of view.

Following the early work of Pieters (1915), studies on the Saprolegniales were initiated by various investigators (Bhargava, 1943, 1945a, 1945b, 1945c, 1946; Leonian and Lilly, 1937, 1938, 1940; Moreau and Moreau, 1940; Saksena and Bhargava, 1941; Saksena and Bose, 1944; Volkonsky, 1932a, 1932b, 1933a, 1933b, 1934; Whiffen 1945). The Saprolegniales grow vigorously on various kinds of media, in which the carbon source may be glucose, maltose, dextrin, starch, or perhaps several other sugars, and some amino acids. Of various sugars tested, however, Whiffen found that *Dictyuchus* can grow vigorously only on glucose, and Volkonsky determined that *Aphanomyces* can utilize no sugars. Most of the Saprolegniales are probably completely autotrophic for vitamins. On the other hand, some may have partially or completely lost the ability to synthesize biotin (Bhargava, 1946; Leonian and Lilly, 1940, and references cited therein), and in one instance, possibly thiamine (Whiffen, 1938). With the exception of *Dictyuchus* (Whiffen, 1945) and *Brevilegnia* (Bhargava, 1945a, 1945b), members of this group are not able to grow on nitrate or sulfate as sole sources of nitrogen or sulfur, respectively. Whether or not ammonium-N can be used in all instances, however, has not been clearly ascertained (cf. Volkonsky, 1932a, 1932b, 1933a, 1933b, 1934; Leonian and Lilly, 1938; Saksena and Bhargava, 1941; as compared to Bhargava, 1945b; Whiffen, 1945). Nitrogen in the form of amino acids or other compounds, and sulfur, as cystine, methionine, gluthathione, or perhaps hydrogen sulfide or thiosulfate, were found to be generally used by those organisms investigated.

In a closely related group, the Leptomitales, we are limited to the work of Schade (1940) on *Leptomitus* and *Apodachyla*. Both fungi are completely autotrophic for essential vitamins. With regard to their carbon nutrition, however, generalizations cannot be made. *Leptomitus* is unable to assimilate sugars and must be supplied with other sources of carbon (e.g., amino or fatty acids), whereas *Apodachlya* grows vigorously either on sugars or amino acids. Furthermore, *Leptomitus* and *Apodachlya* differ from the Saprolegniales in two basic respects: (1) nitrogen must be supplied in organic combination, since neither nitrate nor ammonium compounds will support growth; (2) both organisms are capable of reducing sulfate to satisfy their sulfur requirements.

Finally, it is necessary to consider the aquatic members (Pythiaceae) of the Peronosporales. Little is known about their carbon nutrition, although the studies of Volkonsky (1934) and the author's work (1949) on *Pythiogeton* have shown that various sugars may serve as suitable sources of carbon. It has been demonstrated conclusively that most of the Pythiaceae are either partially or completely heterotrophic for thiamine, or one of its components, pyrimidine (Cantino, 1949; Fries, 1938; Kavanagh, 1942; Kögl and Fries, 1927; Leonian, 1924; Leonian and Lilly, 1938, 1940; Lilly, 1940; Lilly and Leonian, 1940; Payette and

Perrault, 1944; Robbins, 1938a, 1938b, 1942; Robbins and Kavanagh, 1938a, 1938b; Saksena, 1935, 1939, 1940, 1941). Although Ronsdorf (1935) reported that a "bios" solution had been found to produce growth in four species of *Phytophthora* and in one species of *Pythium*, it is clear that most if not all members of the Pythiaceae are not heterotrophic for biotin. Finally, investigations indicate that sulfate is reduced by several species of *Pythium* (Kincaid, 1929; Leonian and Lilly, 1940; Saksena, 1935, 1940; Volkonsky, 1934), and by *Pythiogeton* (Cantino, 1949), whereas nitrogen, which probably can not be assimilated as nitrate (however, see Hawker, 1939; Ronsdorf, 1935), is used in organic combination and in the form of ammonium compounds.

Although a knowledge of the metabolic processes of aquatic Phycomycetes would undoubtedly be of great help in further elucidating their general biology and phylogenetic relationships, this phase of their physiology is least understood. With the exception of the studies of Schade and Thimann (1940) on *Leptomitus*, of Emerson and Cantino (1948) and Cantino (1949) on *Blastocladia*, and of some rather preliminary respirometric data by Wolf and Shoup (1943) and Shoup and Wolf (1946) on *Allomyces*, our knowledge of the metabolism of the water molds is indeed nebulous. All that can be said from the point of view of comparative metabolism is that *Leptomitus* is a strict aerobe which (1) can oxidatively deaminate certain amino acids, (2) can oxidize various fatty acids to carbon dioxide and water but cannot respire sugars, and (3) carries on a very efficient oxidative assimilation. On the other hand, *Blastocladia*, which is not closely related to *Leptomitus*, (1) will grow actively under extremely low concentrations of oxygen, (2) can dissimilate a number of sugars, and (3) has a fermentative rather than an oxidative type of metabolism.

PHYLOGENY

Although a great deal of interest has centered on the phylogeny of the water molds (Atkinson, 1909; Bessey, 1942; Cavers, 1915; Cook, 1928; Mez, 1929; Petersen, 1909; Sparrow, 1935; Scherffel, 1925; Weston, 1936; and others), mycologists have been particularly handicapped by the lack of factual information necessary for a proper evaluation of evolutionary phenomena. As Sparrow (1943, p. 3) has indicated: "No investigator of these fungi pursues his studies for long before he comes to appreciate the enormous lacunae in our present knowledge of them." Furthermore, in the search for relationships, speculations have been based primarily on comparative morphology and on the mechanism of sexual and asexual reproduction. Any account of phylogenetic relationships of the aquatic Phycomycetes, however, should take into consideration all dynamic aspects of their life processes. The critical study of nutrition and metabolism which has led to the proper interpretation of those physicochemical processes which are characteristic of living entities may ultimately provide important correlative data for an integration of evolutionary phenomena.

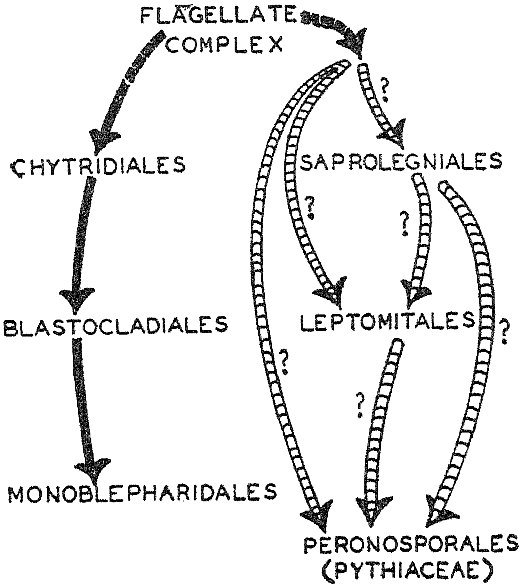

FIG. 1. PHYLOGENETIC RELATIONSHIPS AMONG THE WATER MOLDS, BASED UPON MORPHOLOGICAL AND LIFE-CYCLE CHARACTERISTICS

It has been postulated by Scherffel that aquatic Phycomycetes can be segregated into two main groups, each of which has evolved from different ancestors. He labeled these groups the uniflagellate "Chytridineen" and the biflagellate "Saprolegniineen-Peronosporineen." Sparrow (1943, p. 4) found himself in agreement with the main aspects of Scherffel's thesis "... since they seem best to fit the facts we know now."

The relationships that exist in the aquatic Phycomycetes, based upon life histories and morphological criteria, are summarized in Fig. 1. Two, or perhaps more, distinct series of water molds may have arisen independently from different ancestral groups, which in turn were probably derived from a primitive flagellate complex. The Blastocladiales are closely related to both the Chytridiales and the Monoblepharidales, and apparently bridge the "phylogenetic hiatus" between the two. It is somewhat more difficult, however, to render judgment on any definite point of view with regard to the Saprolegniales-Leptomitales-Peronosporales complex. The Leptomitales show clear and unmistakable affinities with both the Saprolegniales and the Peronosporales, and yet the Peronosporales have many fundamental characters in common with the Saprolegniales. The Peronosporales are primarily terrestrial fungi and only the Pythiaceae can be logically considered as water molds. For this reason, assuming that terrestrial forms were evolved from aquatic ancestors, the Pythiaceae (in the Peronosporales) could be considered as the terminal group of the series, if only one series does indeed exist. Little can be said concerning the relationships of the Lagenidales and Plasmodiophorales to the other orders of aquatic fungi, each of which appears to be composed of clearly related organisms. Until more extensive and precise information on life cycles, sexuality, and physiology is available, they cannot be considered seriously in a discussion of phylogenetic relationships in the water molds.

An approach to the problem of nutritional evolution in microorganisms was made by Lwoff (1932, 1936, 1938, 1944). Although Lwoff has dealt primarily with the protozoans, the general aspects of his thesis may apply to the water molds. In brief, Lwoff postulated a physiological evolution which led to degeneration and heterotrophism, such a progressive loss of capacity for synthesis rendering the organisms more and more dependent upon the environment. It is further assumed that specialization in nutritional requirements is indicative of a highly evolved group, whereas an organism autotrophic for all known vitamins, and which, let us say, can reduce simple inorganic sources of sulfur and nitrogen, would be considered relatively primitive.

It is, of course, possible to conceive of physiological evolution based on a thesis that is diametrically opposed to the one above. For example, the number of biochemical steps involved in the synthesis of proteinaceous materials from inorganic sources of nitrogen and sulfur would presumably exceed that necessary for the same synthesis from assimilable amino acids. Assuming that the greater degree of complexity of a biosynthetic reaction is characteristic of a more highly evolved condition, a microorganism which is capable of assimilating nitrate and sulfate could then be considered advanced, and not primitive (cf. for example van Niel's 1949 discussion on evolution of photosynthesis). If this were used as a basis for phylogenetic relationships among the water molds, however, some fungi which appear to be the most primitive in their morphological and life-cycle characteristics would seem to possess an advanced type of metabolism, and vice versa. For example, the Blastocladiales, usually assumed to have been derived from the Chytridiales, would be characterized by a primitive metabolic mechanism, whereas the chytrids would have to be considered as representing a more highly advanced level of development. Admittedly, from a speculative point of view, physiological evolution may have involved either a progressive loss in synthetic capacities with its associated decrease in complexity of the metabolic mechanism, or a progressive increase in synthetic capacities and a similar increase in complexity of the metabolic mechanism, or both. A consideration of our knowledge of higher plants and animals would seem to indicate that in the main evolution has progressed toward specialization, but with an associated increase in anatomical and morphological complexity. However, as van Niel (1949) has indicated, "it will be necessary to accept the occurrence of a physiological evolution characterized by a loss of synthetic ability, and it is even probable that this is the chief if not the exclusive route by which the vast majority of now living organisms have originated." For the present discussion, it will be assumed that synthetic capacities have evolved, in the sense of Lwoff, toward specialization, with an associated decrease in complexity of biosynthetic reactions.

Such an approach in conjunction with life-cycle and morphological data may help to establish further criteria with which to evaluate phylogenetic relationships in the water molds. Because of the relative lack of physiological criteria for interpreting fundamental relationships, the basic skeleton of any phylogenetic scheme in the water molds must of necessity (for the present) be based solely on morphological and life history data. The author's approach is on this basis. Physiological criteria, then, must be applied from a supplementary point of view. As such, they may provide further standards for judging relationships which are already well-founded on morphological grounds. Furthermore, in instances where morphological evidence is insufficient, it may be possible to use nutritional and metabolic data to shift the emphasis in one direction or another. Thus a more satisfactory explanation of phylogeny might be achieved. Finally, it is of interest to consider nutrition and metabolism per se as a separate entity. Although the biological activities of any organism are the result of many interrelated factors, the progressive losses in synthetic abilities and the fundamental changes which may have occurred in their metabolic processes are in themselves worthy of investigation. It may logically be objected that the production of many single-

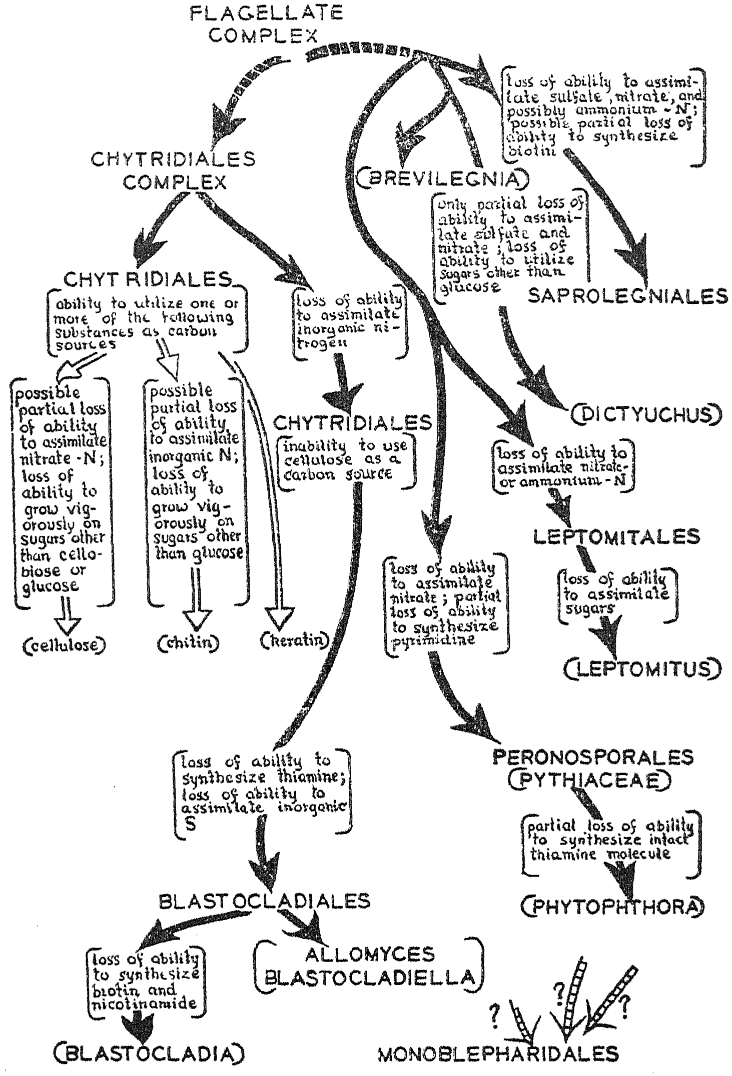
FLAGELLATE COMPLEX
loss of ability to assimilate sulfate, nitrate, and possibly ammonium-N; possible partial loss of ability to synthesize biotin
CHYTRIDIALES COMPLEX
(BREVILEGNIA)
only partial loss of ability to assimilate sulfate and nitrate; loss of ability to utilize sugars other than glucose
SAPROLEGNIALES
CHYTRIDIALES
ability to utilize one or more of the following substances as carbon sources
loss of ability to assimilate inorganic nitrogen
possible partial loss of ability to assimilate nitrate-N; loss of ability to grow vigorously on sugars other than cellobiose or glucose
possible partial loss of ability to assimilate inorganic N; loss of ability to grow vigorously on sugars other than glucose
CHYTRIDIALES
inability to use cellulose as a carbon source
(DICTYUCHUS)
loss of ability to assimilate nitrate or ammonium-N
LEPTOMITALES
loss of ability to assimilate nitrate; partial loss of ability to synthesize pyrimidine
loss of ability to assimilate sugars
(cellulose)
(chitin)
(keratin)
(LEPTOMITUS)
loss of ability to synthesize thiamine; loss of ability to assimilate inorganic S
PERONOSPORALES (PYTHIACEAE)
partial loss of ability to synthesize intact thiamine molecule
BLASTOCLADIALES
(PHYTOPHTHORA)
loss of ability to synthesize biotin and nicotinamide
ALLOMYCES BLASTOCLADIELLA
?
?
?
(BLASTOCLADIA)
MONOBLEPHARIDALES

FIG. 2. PHYLOGENETIC RELATIONSHIPS AMONG THE WATER MOLDS, BASED UPON NUTRITIONAL CHARACTERISTICS.

The term "loss of ability" is restricted in meaning. Most investigations of nitrogen nutrition in the fungi have attempted to show that a given organism can or cannot use, let us say, nitrate as the sole source of this element. However, in those instances where amino acids are required for growth, it has seldom if ever been shown by analysis whether or not nitrate- or ammonium-N is actually assimilated simultaneously. Therefore, for example, "loss of ability to assimilate nitrate" implies that this substance, *when used as the sole source of nitrogen*, will not support growth.

gene biochemical mutants in *Neurospora* without associated morphological changes should presuppose caution in emphasizing nutritional criteria in evolutionary phenomena. If such results are ultimately obtained among the aquatic Phycomycetes, where biochemical genetic studies have not been made, physiological characteristics may still prove to be significant in a relatively homogeneous morphological framework where other criteria are not available.

The relationships among the water molds may now be considered on a nutritional basis (Fig. 2). In the uniflagellate series, any definite conclusion is necessarily premature. The Blastocladiales, which have lost the ability to synthesize thiamine, cannot decompose cellulose, and cannot grow on inorganic sources of nitrogen, appear to have been derived from the chytrids, whose nutritional requirements are somewhat less exacting. The fact remains, however, that only a small fraction of the chytridialian complex has been studied in pure culture; whether or not a narrow range of synthetic abilities characterizes the group as a whole is not known. In the Blastocladiales, a representative of each genus has been investigated, and the results of the studies of vitamin and nitrogen nutrition are generally consistent. Finally, although nutritional criteria may be useful in reflecting on the derivation of the Monoblepharidales nothing is known of their nutrition and metabolism, and further consideration must wait until physiological data are available. In conclusion, it is impossible to decide if evolution in the uniflagellate series has been entirely developmental and morphological, occurring within a nutritional framework encompassing either a narrow or a wide range of synthetic ability; or if synthetic capacities have evolved in a unidirectional manner within the heterogeneous morphological framework of this group.

Assuming that zoospore flagellation is a character of fundamental import in phylogenetic considerations, the biflagellate series has evolved along an independent path from that of the uniflagellate complex. Using this as a basic hypothesis, we come to a consideration of their losses in synthetic capacities, based upon the results of a relatively large number of investigations. Only two organisms, *Dictyuchus* and *Brevilegnia*, which are obviously saprolegniaceous fungi in their morphological and sexual characteristics, seem to differ appreciably from the other members of the order. They are less specialized than most of the Saprolegniales in their ability to utilize sulfate and nitrate, whereas the group as a whole has lost the ability to grow on such sources of sulfur and nitrogen. It is possible that some members of the order may no longer be able to synthesize biotin, but the evidence indicates that most of them are completely autotrophic for vitamins.

Although the Leptomitales have completely lost the ability to grow on inorganic sources of nitrogen, they have retained their capacity to reduce sulfate. The latter characteristic would tend to place them in a distinctly different category from that of the Saprolegniales; they seem, indeed, to have evolved along a completely independent path.

Finally, the aquatic members of the Peronosporales have certain characteristics in common which set them apart from the two foregoing groups. Almost all of the Pythiaceae have suffered a partial or complete loss of ability to synthesize thiamine, and in some cases only the pyrimidine half of the molecule is produced. They differ basically, therefore, from the Leptomitales and Saprolegniales, neither of which requires thiamine. Evidence indicates that whereas the Pythiaceae have not lost the ability to reduce sulfate and thus resemble the Leptomitales, they are able to use ammonium-nitrogen but cannot grow on nitrate alone.

Is it significant that nutritional requirements, at this stage in our knowledge, are rather consistently different among these three major orders? It is not implied that a sharp dichotomy exists between those organisms requiring organic N and those which can use inorganic N such as ammonium compounds, since the loss of ability to synthesize one of any number of amino acids would result in a dependency upon a supply of organic N. The number of essential S-containing compounds is much more limited, and the ability or inability to reduce sulfate would seem to be of greater significance. It is supposed, then, that progressive losses in the synthetic capacities of the Saprolegniales-Leptomitales-Peronosporales complex have evolved along two independent paths, one having given rise to the Saprolegniales, and the other to the Peronosporales and Leptomitales. From a strictly nutritional point of view, the Leptomitales are therefore more closely related to the Peronosporales than to the Saprolegniales.

The foregoing discussion when considered in toto points clearly to the fact that no one set of criteria can be considered exclusive of all others in appraising phylogenetic relationships. For example, if nutritional criteria alone were to be employed in such evaluations, it would be possible to hypothesize that the Peronosporales gave rise to the Blastocladiales. This would have involved a loss of capacity to reduce sulfate, with further losses in the synthetic abilities of *Blastocladia* to produce other essential vitamins. On the basis of morphological evidence and the details of life histories in these two groups, such an hypothesis would be absurd. In the Saprolegniales-Peronosporales-Leptomitales complex, however, where the relationships within the group are not yet reasonably clear, it is possible to show how nutritional characteristics may have been evolved. It is evident that nutritional criteria need not have evolved during the same time interval, indeed not even along the same paths, as those other criteria based on morphology and life histories. It is not necessarily implied that because the nutritional characteristics of the Leptomitales and Peronosporales seem to have evolved along different lines from the Saprolegniales, the evolution of morphological criteria should follow this same pattern. Future investigations of the biology of the water molds will undoubtedly help the mycologist to determine whether or not the nutritional evolution of the group can be reconciled with existing morphological relationships.

SUMMARY

A survey of the literature indicates that there exist inter-ordinal differences in the nutritional requirements of the aquatic Phycomycetes.

1. In the uniflagellate series, those Blastocladiales which have been investigated appear to be more highly evolved, in the sense of Lwoff, than the Chytridiales; but the evidence is insufficient to warrant any far-reaching generalization.

2. In the biflagellate series, the Leptomitales and the aquatic members of the Peronosporales are more closely related to one another in their synthetic capacities than either is to the Saprolegniales.

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CYTOCHEMICAL REACTIONS OF NUCLEIC ACIDS

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In current biological and biochemical research a great deal of attention is being directed toward the nucleic acids and nucleoproteins and the role, or roles, which they play in life processes. Through the efforts of the cytochemist the nucleic acids may be identified, localized, and quantified within individual cells. Such cytochemical observations afford an important link between the chemistry of tissue extracts and the physiology of the living cell. As Danielli has emphasized (1946, 1947), the validity of the observations, and consequently of the hypotheses drawn from them, depends on the reliability of the methods by which the material is prepared. Although some of the older papers dealing with the cytochemical techniques have been summarized in the reviews by Gersh (1941) and Dempsey and Wislocki (1946), there has been no comprehensive review of the more recent literature. The purpose of this paper is to review the most pertinent literature concerning the cytochemical techniques for studying the nucleic acids and to discuss their validity as specific tests.

When the cytochemist attempts to interpret the results of qualitative or quantitative tests run on tissue sections, he is confronted with many unique and baffling problems. Chemical reactions within the cell are seldom, if ever, subject to the controlled conditions of test-tube chemistry, but take place within the peculiar chemical and physical conditions found in protoplasm. Furthermore, most of the present cytochemical reactions are run on dead cells. Since very little is known of the effect of death by various causes on the physical and chemical condition of protoplasm, any attempt to extrapolate from the dead to the living state is fraught with danger. Thus, the very nature of the material imposes on the cytochemist limitations which must be kept in mind in evaluating the techniques and in interpreting the results.

More specifically, in considering the validity of any cytochemical technique, special consideration should be given to the following points: (1) the specificity of the chemical reaction between the substance to be identified and the test reagents, (2) the accuracy and the ease with which the reaction product may be detected within the cell, (3) the degree to which the protoplasmic constituents are retained with a minimum distortion from the living conditions, (4) the extent to which the protoplasmic constituents or the reaction products are diffusible, (5) the degree to which the reacting groups come into contact with each other and are free to react, that is, are not bound in such a way that the expected reaction cannot occur. If quantitative determinations are desired, consideration must be given to such additional factors as: (6) the number of reacting groups which may be involved in the dye binding or the color reaction, (7) the orientation and aggregation of the reacting protoplasmic material or the reaction products, (8) the exact thickness of the cytological preparation, and (9) the sensitivity and accuracy of the means of determining the amount of light absorbed by the specific compounds being analyzed.

SPECIFICITY OF THE REACTION

1. Chemistry of the Nucleic Acids

Information concerning the chemical properties of the nucleic acids is essential for any discussion of the specificity of the cytochemical tests. For this, the cytochemist is dependent on the results of chemical investigations. Since the chemistry of the nucleic acids has recently been thoroughly reviewed (Chargaff and Vischer, 1948; Gulland, Barker, and Jordan, 1945; Loring, 1944) and its various aspects have been extensively discussed in the three symposia held in 1947 (Cold Spring Harbor Symposia on Quantitative Biology, *12*; Symposia of the Society for Experimental Biology, *1*; Symposium on the Chemistry and Metabolism of Nucleic Acids and their Constituents, Federation Proceedings, *6*), a detailed review of the literature will not be given here. Only those facts and concepts which are of special significance to the cytochemist will be discussed.

A comparison of the information and viewpoints expressed in the older reviews (Levene and Bass, 1931; Allen, 1941; Mirsky, 1943; Greenstein, 1944) with those of the more recent papers shows that the concepts concerning the chemistry of the nucleic acids have changed greatly within the last few years. The present state of knowledge of the nucleic acids has been compared with that of the proteins at the beginning of this century (Chargaff and Vischer, 1948). Not only is there a relatively small amount of well established information, but also many of the data which were obtained by the earlier investigators are now regarded with suspicion because of serious faults in the techniques they used. This state of affairs has led to considerable confusion in the biochemical literature, and the confusion has often been reflected in the cytochemical papers.

That the nucleic acids can be grouped into two main types on the basis of easily detectable chemical differences has been known since the early days of nucleic acid chemistry. Various terms, such as thymonucleic or desoxyribonucleic acid, and yeast or ribonucleic acid, have been used to distinguish the two types. Since a complete characterization of the hydrolytic products has been carried out for nucleic acids from only a few types of material, more accurate terms for the designation of those nucleic acids in which the sugars have not been identified are desoxypentose nucleic acid and pentose nucleic acid. Substances identified in the hydrolytic products from such typical desoxypentose nucleic acids as fish sperm and beef thymus extracts are: 2-desoxy-D-ribose, two pyrimidines (thymine and cytosine), two purines (adenine and guanine), and phosphoric acid. Substances identified in pentose nucleic acid hydrolysates of such thoroughly studied materials as yeast, pancreas, liver, and tobacco mosaic virus, are: D-ribose, two pyrimidines (uracil and cytosine), two purines (adenine and guanine), and phosphoric acid (Levene and Bass, 1931; Gulland, Barker, and Jordan, 1945; Chargaff and Vischer, 1948). These results suggest that the component substances in the two types of nucleic acid are the same except for the presence or absence of an hydroxyl group on carbon 2 of the pentose sugar and of a methyl group on carbon 5 of one of the pyrimidine bases.

The fact that these products are consistently obtained from nucleic acids gave rise to an assumption, formerly widely accepted, that there are only two kinds of nucleic acids and that they have a relatively constant composition. In a recent critical review of the older analytical work, Gulland (1947a) pointed out that the yield of known substances in hydrolyzed nucleic acids is far from quantitative and that little serious effort to identify other substances seems to have been made. Many of the most widely used biochemical tests detect only groups within the molecule, such as pentose sugars, desoxycarbohydrates, or some of the purine or pyrimidine groupings. The careful, complete identification of the hydrolytic compounds is often neglected. Furthermore, the drastic chemical procedures usually used in extracting, purifying, and hydrolyzing the nucleic acids may very well destroy certain groups, fail to liberate others, lead to interconversion of compounds, or in other ways produce artifacts. In view of these factors, a number of the most competent of modern biochemists (Gulland, Barker, and Jordan, 1945; Gulland, 1947a, b; Loring, Ordway, Roll, and Pierce, 1947; Vischer and Chargaff, 1948) have felt that in most instances the data are not sufficiently precise to permit definite conclusions concerning the composition of nucleic acids. If the nucleic acids cannot be regarded as having a constant composition, it follows that conclusions from cytochemical tests can be drawn only for the specific group which the procedure detects.

In considering the nucleic acids of the cell, of course, neither the biochemist nor the cytochemist is dealing with the separate components but rather with a complex nucleic acid molecule or macromolecule. Thus, the way in which the components are combined in the protoplasmic complex becomes of great importance. It has long been known that hydrolysis of isolated and purified nucleic acids yields nucleotides, each of which consists of a sugar, a nitrogen base, and phosphoric acid. Alkaline hydrolysis of a purified nucleotide preparation, or of the intact nucleic acid molecule itself, will split off phosphoric acid, leaving a base-sugar complex termed a nucleoside. On the other hand, the nitrogen bases may be removed by acid hydrolysis, leaving phosphoric esters of the sugar. The ease with which the bases are split off varies with the different types; the purines are liberated by a relatively mild acid hydrolysis, while the pyrimidines are split only by much more drastic treatment (Osborne and Heyl, 1908; Vischer and Chargaff, 1948). Many of the details concerning the nature of the linkages between the components of the individual nucleotides have been determined (Gulland, 1947b; Lythgoe and Todd, 1947). It is generally accepted that sugar-phosphate ester linkages bind the mononucleotides together, but the exact structure of none of the polynucleotides is completely known (Gulland, 1947b; Chargaff and Vischer, 1948).

The early investigators found the quantitative yields of the hydrolytic products of nucleic acids to be in keeping with the hypothesis that four mononucleotides, each containing one of the four different bases, are united in a fixed pattern to form a basic tetranucleotide out of which larger molecules are formed. Recent investigations, however, have indicated that neither the concept of a structural tetranucleotide with regularly arranged components nor that of a statistical tetranucleotide with the components present in equimolecular proportions is in harmony with all of the known data (Gulland, 1947a, b; Gulland, Barker, and Jordan, 1945; Loring, Ordway, Roll, and Pierce, 1947; Vischer and Chargaff, 1948). Thus, it is possible that nucleic acids present in different organisms, in different types of cells, or in the same cell at different physiological or developmental stages, may differ both in the number and kinds of nucleotides present and in their arrangement within the polynucleotide structure.

Since both types of nucleic acids may be obtained from tissue extracts in the form of large, highly asymmetric particles (Greenstein, 1944; Fletcher, Gulland, Jordan, and Dibben, 1944), it has usually been concluded that the nucleotides are present in the cell in a highly polymerized condition. The desoxypentose nucleic acids, in general, appear to be more highly polymerized than the pentoses. However, the data showing that particle size may vary with the extraction procedures and the subsequent treatment of the solution (Gulland, Barker, and Jordan, 1945) suggest that processes of polymerization or depolymerization may take place during the chemical procedures. In view of evidence of this nature, caution should be used in extrapolating from the physical properties found in solutions of isolated nucleic acids to the condition in living protoplasm.

These large complex polynucleotides, still imperfectly understood chemically, are the substances which the cytochemist attempts to detect and to localize within the cell. Up to the present time only a few techniques for doing this have been developed, all of which are based on reactions with only one of the components or with a specific group within the molecule. The Feulgen reaction is used to detect the presence of a desoxypentose. Basic stains supposedly react with the acidic groups of both pentose and desoxypentose nucleic acids. The specificity of the stain reaction is often tested by combining staining procedures with a treatment of adjacent sections with agents that remove the nucleic acids, i.e., ribonuclease, desoxyribonuclease, and acid hydrolysis. Special apparatus, constructed to measure the ultraviolet absorption in cytological preparations, may detect the characteristic absorption of the purine and pyrimidine skeletons of the nucleic acid molecule. A positive reaction with any one of these tests may be indicative of the presence of nucleic acid within the cell.

2. *The Feulgen Reaction*

One of the most widely used cytochemical reactions is the test, first worked out by Feulgen and Rossenbeck (1924), for the sugar obtained by hydrolysis of desoxypentose nucleic acid. Many modifications of the original technique have been made, but the ones most often employed are the procedures of de Tomasi (1936) and Stowell (1945). Essentially, the reaction consists of two parts: a short hydrolysis with normal hydrochloric acid heated to 60° C., followed by reaction of the hydrolyzed sugar with leucofuchsin to produce a magenta-colored compound. Neither unhydrolyzed desoxyribonucleic acid nor ribonucleic acid give this reaction. Since the Schiff's fuchsin-sulfurous acid reagent used in the Feulgen test has long been used as a qualitative test for aldehyde groups, the assumption is made that the effect of hydrolysis is to liberate free aldehyde groups in the desoxyribose molecule. The purplish-red compound formed by the Schiff reaction is generally thought to be a complex formed by the union of the free aldehyde with the decolorized pararosaniline (Rumpt, 1935; Schriner and Fuson, 1944).

The chief discussions concerning the validity of the technique as a specific cytochemical test have arisen from the difficulty of determining the exact effect of hydrolysis on the desoxyribonucleic acid in a tissue. Within the last year several reports of chemical and cytochemical studies on the effect of Feulgen hydrolysis have been made (Di Stefano, 1948a, b; Overent and Stacey, 1949; Li and Stacey, 1949; Ely and Ross, 1949a).

There is general agreement that one of the first, if not the first, effect of hydrolysis in normal hydrochloric acid at 60° C. is a liberation of purines. Li and Stacey (1949) have succeeded in isolating purines in the crystalline form and as picrates from hydrolysates of desoxyribonucleic acid. Most investigators, however, have not actually isolated the purines but have used characteristic ultraviolet absorption at 2600 Å as indicative of their presence. The reason for thinking that the absorbing substances are largely purine rests on chemical evidence that very drastic procedures, such as autoclaving at 175° C. for several hours (Vischer and Chargaff, 1948), are required to remove pyrimidines from desoxyribonucleic acid.

As a result of their experiments, Stacey and his coworkers (Li and Stacey, 1949; Overent and Stacey, 1949) concluded that the splitting of the glycosidic purine-desoxyribose linkages permits the shifting of a significant portion of the sugar from the furanose to the aldehydo configuration, thus freeing aldehyde groups for reaction with the Feulgen reagent. Since the colored complex formed after a short hydrolysis is insoluble, they concluded that the sugars are still bound in the polynucleotide chain by their phosphate linkages. Li and Stacey also presented evidence that procedures which result in a change in the physical state of the macromolecule, such as depolymerization, also liberate aldehyde groups.

It has been suggested by Li and Stacey (1949) and Di Stefano (1948a, b) that during the period of time required for the attainment of a maximum intensity of stain there is a progressive splitting of purines and freeing of aldehyde groups and that few, if any, additional changes occur. A point of maximum intensity of the Feulgen reaction was found to be reached after 12 minutes of hydrolysis by Di Stefano (1948b), and after 20 to 30 minutes by Ely and Ross (1949a). Both Bauer (1932) and Hillary (1939) found that the time required to reach a maximum intensity varies with the fixatives used in preparing the tissues; if solutions containing chromic acid are used the time varies from 5 to 30 minutes, while tissues fixed in solutions not containing chromic acid require only 4 to 8 minutes. The exact time for the attainment of maximum intensity of reaction is thus seen to vary under different experimental conditions. The above investigators also found that there is a progressive diminution in the intensity of the reaction if the time of hydrolysis is continued beyond the time of maximum reaction. Bauer (1932) and Hillary (1939) found that the stain is retained without obvious loss of color much longer if chromic acid is present in the fixatives than if it is missing.

Evidence from cytochemical studies of substances remaining in tissue sections and from chemical studies of products released into the hydrolysates from tissues indicates that continued hydrolysis results in degradation of the nucleic acid molecule. Stedman and Stedman (1943a; 1947), Danielli (1947); Li and Stacey (1949), and Ely and Ross (1949a) have demonstrated that the supernatant fluid from hydrolysis of purified desoxyribonucleic acid contains water-soluble, Feulgen-positive substances. Ely and Ross also made nitrogen and phosphorus determinations and ultraviolet studies of the substances found in the dialysates of hydrolyzed fixed, macerated thymus tissue. After 30 minutes of hydrolysis, they found nitrogen-containing compounds which absorbed in the ultraviolet, but no phosphorus. After hydrolysis of 5 hours, both nitrogen and organic phosphorus compounds were found in the dialysate. Overent and Stacey (1949) found that by increasing the acidity of the hydrolytic mixture up to pH 3.6 a great variety of soluble and insoluble fractions, including guanine, adenine, and desoxyribose phosphates, as well as other fragments difficult to characterize precisely, are formed. In view of these results, it must be concluded that acid hydrolysis of desoxyribonucleic acid may lead to the formation of small, diffusible degradation products.

It has also been demonstrated that prolonged hydrolysis of tissue sections results in the loss of all the detectable groups of the nucleic acid molecule. Di Stefano (1948b) and Ely and Ross (1949a) alike found that during prolonged hydrolysis in normal hydrochloric acid at 60° C. there is a progressive loss of material absorbing ultraviolet at 2600 Å, of Feulgen-reactive material, and of substances possessing affinity for basic stains. Ely and Ross also demonstrated by microincineration studies that after 30 minutes of hydrolysis very little inorganic ash is left in tissue sections. The rapidity with which the Feulgen-positive material is removed from the nuclei has been shown to vary with the fixative used in the preparation of the tissue (Bauer, 1932; Hillary, 1939; Di Stefano, 1948).

The demonstration of the formation from desoxyribonucleic acid of hydrolytic products which produce colored, water-soluble complexes on reacting with the Schiff's reagent led Stedman and

Stedman and other investigators of the Edinburgh laboratories (Stedman and Stedman, 1943a, b, 1944, 1947; Choudhuri, 1943; Carr, 1945) to criticize the validity of the Feulgen technique for locating desoxyribonucleic acid. They have maintained that the nucleic acid is located largely, though not necessarily exclusively, outside the chromatin and that the water-soluble dye formed as a result of the Feulgen reaction is adsorbed by a specific protein, chromosomin, in the chromosome. Histochemical evidence that the desoxyribonucleic acid is localized within the chromatin material and thus that the Stedmans' claims cannot be correct has been presented by Callan (1943), Barber and Callan (1944), Caspersson (1944), Stowell (1945, 1946a), Dodson (1946), and Brachet (1946, 1947). Stacey and his coworkers and Di Stefano have felt that their chemical evidence also refutes the Stedmans' idea that the colored structures are the result of non-specific staining by soluble dye complexes. They have pointed to their evidence that in the early hydrolytic phases of the Feulgen reaction the chief change is the splitting of the purine-sugar linkages and that after this the sugars are still bound in the polynucleotide chain. Ely and Ross, on the other hand, thought it had not been clearly determined whether the depolymerization of the nucleic acid precedes or follows the splitting off of purines, and hence that the Stedmans' contention could neither be affirmed nor denied.

One additional point in evaluating the specificity of the Feulgen technique should be discussed. It must be ascertained that under the conditions of the test the desoxyribonucleic acid is the *only* substance that will react with the Feulgen reagent. Since most free aldehydes, and certain other groups, may oxidize leucofuchsin, it is to be expected that a number of protoplasmic substances will produce a colored compound by reacting with the Schiff's reagent. The appearance of color has been reported following the addition of decolorized fuchsin to myelin sheaths of nerves, adipose tissue, secretory granules of fresh pancreas and adrenal gland (Liang, 1947), glycogen, starch, and lignins (Bauer, 1933; Hillary, 1939). It is possible, however, to distinguish these substances from desoxyribonucleic acid because all of them give the reaction without the previous hydrolysis which is necessary for the nucleic acid test. In certain tissues, particularly after fixation with mercuric chloride, a cytoplasmic reaction occurs with the Feulgen reagent even after hydrolysis. It has been suggested that a lipoprotein substance, sometimes termed "plasmalogen," (Hillary, 1939; Stowell, 1945) is responsible for this reaction. The distinction between tissue aldehydes and the groups released by hydrolysis of desoxyribonucleic acid may be made by a technique devised by Danielli (1949) in which the tissue aldehydes are rendered inactive by treatment with hydroxylamine prior to hydrolysis.

In summary, it may be concluded that the Feulgen reaction results in the formation of a colored substance by the reaction of the aldehyde groups freed by acid hydrolysis of the desoxypentose nucleic acid with reduced fuchsin. In the opinion of the majority of investigators, this reaction takes place in situ, provided a time of hydrolysis only sufficient to produce a maximum coloration is used. However, in view of the criticisms that have been raised, conclusions concerning the precise localization of the nucleic acid should be accepted with some reservation, and if possible checked by comparison with other cytochemical tests. As a quantitative technique the Feulgen reaction is subject to even greater criticism. As Ely and Ross (1949) have pointed out, quantitative measurements would have little value if the hydrolytic procedures remove some of the depolymerized fragments. Furthermore, neither the number of purine-sugar linkages that exist in polynucleotides of different types, nor the number of aldehyde groups freed by the hydrolytic procedures have been precisely determined. Thus, it is difficult to determine the relationship between the dye-binding groups and the amount of purine nucleotides. At best, such calculations would completely ignore the pyrimidine components of the nucleic acid.

3. Basic Staining

It has long been known that nuclei and certain cytoplasmic components possess a strong affinity for basic stains. Procedures for using the basic stains have not been standardized, and great variation in the strength of stain, staining and destaining procedures, and the use of fixatives prior to staining is to be found in the literature. A complete, concise compilation of the different techniques used has recently been published in tabular form by Lillie (1949).

The fact that structurally different dyes, resembling each other chiefly in the possession of basic radicals, give good staining reactions with cell parts containing nucleic acid supplies circumstantial evidence that the process of staining involves an acid-base reaction. Michaelis' study of the reaction between purified solutions of yeast nucleic acid and some of the basic dyes (toluidine blue, thionin, methylene blue, and pyronin) showed that a salt-like union between the dye and the nucleic acid molecule occurs. Kurnick and Mirsky (1950) have studied the stoichiometry of the reaction between methyl green and the desoxyribonucleic acids found in fixed nuclei and obtained from purified extracts. They found that if the temperature and pH are controlled, there is a constant ratio of one dye molecule to ten phosphorus atoms in the dye-nucleic acid complex. They also found that histone and lanthanum compete with the basic dye in the reaction with desoxyribonucleic acid and have interpreted this as indicating that all three basic compounds have a common site, presumably the phosphoric acid groups, of attachment to the nucleic acid molecule.

Evidence is available, however, that indicates that the reaction between basic dyes and nucleic acids is not merely a simple ionic union. Kurnick (1950a) found that while all triphenylmethane dyes with *two* amino groups react specifically with highly polymerized nucleic acid, those triphenylmethane dyes with *three* amino groups are not specific. He proposed an hypothesis involving stereochemical factors to explain the difference in behavior of these closely related dyes. Many workers (Lison, 1935a, b; Kelly and Miller, 1935a, b; Michaelis and Granick, 1945; Michaelis, 1944) have shown that the color of metachromatic basic dyes depends on the nature of the acid in the dye-acid complex, thus indicating that different kinds of chemical unions change the optical properties of the dye.

Michaelis (1947) reported that, if the specific dyes are allowed to react with the nucleic acids in tissue sections, a strong ionic bond will hold the dye to the nucleic acid, while the excess dye which is adsorbed or loosely bound within the cell is removed by washing with water or alcohol.

On the basis of Michaelis' opinion that prolonged washing in alcohol (in the absence of any precise statement, it may be assumed that he referred to 95 per cent ethyl alcohol) will remove non-ionically bound stain, Di Stefano (1948b) concluded that the methyl green left in sections after overnight destaining in isopropyl alcohol is bound to the nucleic acid. For the same reason Pollister and Leuchtenberger (1949b) destained sections stained in methyl green overnight in 95 per cent alcohol. However, when methyl green was combined with pyronin in the Unna-Pappenheim stain, destaining was carried out in tertiary butyl alcohol. The rapidity with which sections that have been stained with methyl green, methyl green-pyronin, and toluidine blue will destain has been found to vary with the kind of alcohol used (Lumb, unpublished data).

Special consideration should be given to a mixture of two basic dyes which has been used a great deal, especially by Brachet (1940, 1944), for the differential staining of both nucleic acids in the same preparation. This is Unna's modification of the Pappenheim mixture of methyl green and pyronin. According to Brachet, under the conditions of the staining procedure there is a competition between the ribo- and desoxyribo-nucleic acids, so that the methyl green unites with the desoxyribo- and the pyronin with the ribo-nucleic acid. Kurnick, in the discussion following Michaelis' paper (1947) and in a later paper (1950a) presented the results of studies of the reactions of pyronin and methyl green on the two types of nucleic acids and nucleoproteins in different polymerization states. As a result of his experiments, Kurnick concluded that methyl green adheres more firmly to the higher polymers of either ribose or desoxyribose nucleic acid, while pyronin reacts more strongly with the lower polymers. He suggested that, since desoxyribonucleic acid is believed to be present in the cells in a more highly polymerized state than ribonucleic acid, the reaction of Unna's mixture reflects the relative states of polymerization rather than any specific chemical difference in the molecules. Another interesting phenomenon which accompanies methyl green staining has been observed by Pollister and Leuchtenberger (1949b), who found that after treating sections with hot water the chromatin no longer stains with methyl green, although a positive Feulgen test and ultraviolet studies indicated that desoxyribonucleic acid is still present. Gross analysis of liver tissue before and after hot water treatment showed no reduction in the amount of phosphoric acid. Pollister and Leuchtenberger concluded that the loss of stainability of the chromatin is due to a change in the physical state, presumably depolymerization, of the nucleic acid. Kurnick (1950a, b) also found that exposure of tissues to heat, 60°C for ten minutes, results in the loss of nuclear affinity for methyl green, presumably due to the depolymerization of the desoxyribonucleic acid.

If the nature of the reaction of the nucleic acids with the basic dyes is primarily an acid-base attraction, there is no reason to suppose that other strongly acidic protoplasmic components will not also stain. The mucoproteins, found principally in mucin, chondrin, and the basophilic granules of mast cells (Hempelmann, 1940; Holmgren and Wilander, 1937; Holmgren, 1940; Asplund, Borell, and Holmgren, 1940) are highly acidic because of the sulfuric acid radical on the hexosamine carbohydrate. The reaction of many of the basic dyes, such as toluidine blue, thionin, or polychrome methylene blue, toward acidic substances is metachromatic; the sulfuric acid esters of the mucoproteins stain a violet to red color, while the phosphoric acid esters of the nucleoproteins give a blue color. Thus, in some instances at least, the muco- and nucleo-proteins may be distinguished by the shade of basophilia. Holtfreter (1946) found that fatty acids, rancid fats, and phosphatides react with toluidine blue and methylene blue to give a blue violet color. Since fat solvents are customarily used in dehydrating and embedding, the possibility of fats or fatty acids remaining in cytological preparations is slight.

4. *Basic Staining Combined with Enzymatic or Hydrolytic Removal of the Nucleic Acids*

Although some investigators, such as Pollister and Leuchtenberger (1949a, b), Di Stefano (1948a, b), and Kurnick (1950b), have felt that under their staining conditions the basic dye reacts specifically with the nucleic acid, the general consensus seems to be that too great a reliance should not be placed on staining alone. Fortunately, a complementary procedure has been devised which, when used with basic staining, permits greater assurance in the detection of nucleic acids. In this technique, first used by Brachet (1940), adjacent sections of a tissue are given identical treatment except for the incubation of one of them with a specific nuclease. After the two slides are stained, inferences as to the location of the nucleic acids are drawn from the absence of basophilia in the digested section. The validity of this technique, of course, depends on the specificity of the action of the enzyme.

The nuclease most extensively used in histochemical tests is the one, first obtained from the pancreas by Jones (1920), which brings about the breakdown of large pentose nucleic acid molecules without the release of either phosphoric acid or nitrogen bases. This enzyme, variously termed ribonuclease, ribonucleinase, ribonucleotidase, ribonucleodepolymerase, has been shown to act specifically on ribonucleic acid to form small, diffusible units. The isolation and crystallization of ribonuclease by Kunitz (1940) have permitted more accurate studies of its activity than were possible with crude preparations. A further refinement in the method of preparation developed by McDonald (1948) made possible the preparation of a crystalline product free from all measurable traces of proteolytic activity. When cytological preparations are incubated in a solution of ribonuclease it is presumed that, if given sufficient time for the enzyme to act, the nucleic acid is completely degraded and the small units diffuse from the tissue. Stowell and Zorzoli (1947) have investigated the effects of varying the fixation of the tissues and such factors as concentration of the enzyme, temperature and time of the reaction, and the type of buffering solutions, on the action of ribonuclease. These authors have emphasized the necessity for carefully controlling the conditions of the test before considering the action of ribonuclease as specific.

In considering the action of ribonuclease, it should be pointed out that chemical tests have shown that regardless of the time allowed for enzyme action, a relatively large fraction, as much as 50 per cent, of the nucleic acid is not broken into diffusible units and appears to be resistant to the action of the enzyme (Kunitz, 1940; Loring, Carpenter, and Roll, 1947; Schmidt, Cubiles, Swartz, and Tannhauser, 1947; Bacher and Allen, 1949). It has also been demonstrated by Loring et al. and Schmidt et al. and by Bacher and Allen that pyrimidine nucleotides are found more abundantly in the diffusible products, while the purine groups tend to remain in the fraction resistant to enzymatic action. Although the significance of this differential action of ribonuclease on the nucleic acid is not understood, it suggests that more than one kind of linkage binds the mononucleotides together. These findings of the chemists indicate that the cytochemist cannot interpret the loss of basophilia in a section exposed to enzyme action as necessarily indicating a complete loss of ribonucleic acid from the tissue.

Enzyme preparations which bring about a degradation of desoxyribonucleic acid have also been studied (Greenstein and Jenrette, 1941a, b; Cohen, 1945; Schmidt, Pickels, and Levene, 1939; McCarty, 1946). Although Kunitz (1948) has reported the isolation and crystallization of the enzyme, few reports on the properties and activity of the purified product have been published. Zamenhof and Chargaff (1949) have found that even after prolonged digestion of desoxyribonucleic acid with crystalline desoxyribonuclease a core of non-diffusible material remains. This enzyme has not yet been extensively used in histochemical tests, but Brachet (1946, Brachet and Shaver, 1948) used a crude preparation and reported that it causes a specific loss of basophilia from nuclear chromatin.

Another cytochemical technique which is similar in some respects to the digesting-staining procedures just discussed is one in which the large molecules are degraded by hot acid hydrolysis. Schneider (1945) found that heating macerated fresh tissues for 15 minutes in 5 per cent trichloracetic acid at 90° C. removes all of the nucleic acids. Pollister and Ris (1947) and Brachet and Shaver (1948), assuming that similar acid hydrolysis of fixed tissues would have the same effect on the nucleic acids, have utilized this procedure to remove the nucleic acids from tissue sections. They reported that all basophilic material and all substances absorbing ultraviolet light in the wave-lengths characteristic of nucleic acid are removed by the trichloracetic acid hydrolysis.

Pouyet (1949) has demonstrated by chemical analysis that hydrolysis of fixed, macerated tissues with normal hydrochloric acid at 60° C. for 10 minutes will remove most of the ribose- and very little of the desoxyribose-nucleic acid. Cytochemical demonstrations that similar mild acid hydrolyses result in the loss of basophilic material from the cytoplasm without observable effects on the basophilia of the nuclear chromatin have been reported by Deane (1946) and Vendrely (1949). Ely and Ross (1949a) found that after 3 to 6 minutes of hydrolysis in normal hydrochloric acid at 60° C. all of the ultraviolet-absorbing material is gone from the cytoplasm and that a hydrolysis of 20 minutes is necessary to remove the ultraviolet-absorbing material from the nucleus. Vendrely (1949) has suggested the use of a 10-minute hydrolysis in normal hydrochloric acid at 60° C. as a substitute for ribonuclease in the location of ribonucleic acid in cells.

5. *Ultraviolet Absorption Techniques*

A technique for the detection of nucleic acids in cytological preparations, based on an entirely different principle, is that of ultraviolet light absorption. Caspersson (1940, 1947) perfected a technique for sending known wave-lengths of ultraviolet light through quartz microscope lenses focused on a portion of the cell and recording the extinction by means of a photographic plate or a photoelectric cell. Caspersson and a group of collaborators, particularly Hydén, Thorell, Engström, Norberg, Santesson, Moberger, Malmgren and Schultz, have applied this technique to a great variety of cellular problems (see Caspersson, 1947, for summary and complete bibliography). Modifications of the technique have also been utilized by other workers, particularly Pollister and his colleagues (Pollister and Ris, 1947; Pollister and Leuchtenberger, 1949a, b; Di Stefano, 1948), and by Gersh and Bodian (1943).

The technical physical problems involved in the accurate measurement of the specific absorption of light by a cellular structure have been carefully worked out by Caspersson. According to his calculations, it is theoretically possible to determine extinctions with an accuracy of 5 per cent for objects down to a size about four times the wave-length of light, that is, about 0.6 μ in the middle ultraviolet. Caspersson has constructed an elaborate apparatus which fulfills the Abbé sine condition for an optical system and insures that all light leaving the object is transferred to the image. He has also devised mathematical corrections for the non-specific losses of light in the system.

It has been shown that most organic substances found in the cell absorb heavily in the ultraviolet and that the nucleic acids have a sharply defined peak between 2570 and 2600 Å. The absorption of the nucleic acids is thought to be due to the properties of the ring structure common to both purine and pyrimidine bases. Thus, identification of these cellular components is possible by determining the absorption spectrum of ultraviolet rays. Photographs taken with light of wave-lengths in the neighborhood of 2600 Å have also been used to detect the presence of nucleotides in tissues. However, photographs cannot be considered as accurate a means of identification as complete absorption curves.

OTHER FACTORS TO BE CONSIDERED IN QUALITATIVE CYTOCHEMICAL TESTS

A prime requisite for any cytochemical technique is that the specific substance must be detectable within the cell. For the nucleic acids, this is entirely dependent on the optical properties of the substances themselves, or the reaction products. Both the basic stains and the leucofuchsin of the Feulgen reaction form colored complexes with nucleic acids which may be detected visibly, and, with the aid of a microscope, located within the individual cell. Danielli (1947) has suggested the possibility of detecting purine and pyrimidine groups by the color of the diazonium hydroxide produced after destructive benzoylation to eliminate possible reactions with other compounds. However, the ultraviolet absorption properties are usually used to detect the nitrogen bases.

It is also important to know that the color is detected in situ. As previously discussed, there has been much controversy over the diffusibility of the Feulgen reaction products. It is usually considered that the fixation and dehydration procedures precipitate or immobilize the chief cellular constituents. It is also recognized that this is accompanied by a certain amount of distortion from the fresh condition. It is to be expected that small, water- or alcohol-soluble molecules, such as simple sugars, free amino acids, dicarboxylic acids, and mononucleotides, will not be fixed and will tend to diffuse from the cell during the process of fixation and dehydration. At the present time, no good way of circumventing these difficulties has been devised.

Since one of the objectives of cytochemical studies is to supply information which may be used in interpreting the functions of living cells, it is important to consider the relationship between the condition of the living cell and the condition of the cell when the test is made. The nature of most of the present cytochemical tests is such that either the cell is killed before starting the procedure or the technique itself damages the cell. Even microscopic observation of normal living, differentiated cell types has been limited by the technical difficulties of making suitable preparations. Furthermore, the criteria for a "good" preparation have not always been derived from a study of living cells but from a standardized picture of what the early cytologists found when they studied fixed material. For example, the living nucleus usually presents a more or less homogeneous appearance in which only the nucleolus is observed as a formed body. Nevertheless, the "typical" cytological nuclear picture is one in which the chromatin is localized into discrete clumps. Furthermore, even though care may be taken to use those procedures which preserve the cellular structures in a condition which optically most resembles the living cell, this cannot be regarded as an adequate indication that the chemical characteristics have not been altered. There is no completely adequate way of knowing the chemical or physical changes undergone by the protoplasmic components during death from various causes, and hence, how closely the test conditions correspond to those of the living cell.

Only a few isolated observations comparing the reactions between living and dead protoplasm have been reported. Michaelis (1947) pointed out that the nucleus of a living cell does not stain at all in a dilute solution of dye of sufficient strength to stain the dead cell. He suggested that on death some irreversible change occurs in the nucleoprotein, so that acid groups, formerly bound, are now free to react with the basic dye group. Ely and Ross (1949a) found that living cells resist the action of desoxyribonucleic acid depolymerase, although the enzyme attacks cells killed by heat, fixatives, and ultraviolet light. It is possible that in both of these cases the permeability of the cell, or nuclear, membrane plays an important role in preventing the substances from coming into actual contact with the nucleic acids of the cell. On the other hand, it is also possible that the explanation is to be found in a different chemical or physical condition in living protoplasm.

Differences in the ultraviolet absorption properties of living and dead cells have also been reported. Brumberg and Larionov (1947; Larionov and Brumberg, 1948) found that the nucleus of a living cell does not absorb ultraviolet. They demonstrated that a relatively short exposure of living cells to ultraviolet rays kills the cell and that the absorption by the nucleus then increases, whereas that of the cytoplasm decreases. Recent investigations of Ris and Mirsky (1949) have verified Brumberg and Larionov's observations. On the other hand, Ludford, Smiles, and Welch (1948) and Ely and Ross (1949b) found that living cells show strong absorption when first observed. Bradfield and Errera (1949) found that as ultraviolet radiation is prolonged different kinds of cells behave in different ways; in some the absorption increases, in others it decreases, and in some it shows little change. Although the significance of these observations of ultraviolet absorption by the cell is not clearly understood, it seems apparent that, in some types of cells at least, there is a difference in the capacity of living and dead protoplasm to absorb ultraviolet rays.

It has long been known that different histological fixatives produce great variations in the optical appearance and stainability of cells. At first the choice of fixative to be used was largely empirical; experience showed that certain fixatives give "good" results with certain stains and tissues, while others do not. With progress in biochemistry, the reasons for the observed effects began to be more clearly understood. Since nucleic acids are unstable in alkaline solutions, they would not be expected to be retained in cells fixed at a high pH. This corresponds with the observation that most good nuclear and cytoplasmic basophilic fixatives contain a relatively high concentration of acetic acid.

The effect of chemical reactions on the amphoteric properties of proteins should be kept in mind in using staining or cytochemical reactions. It has been shown that formaldehyde reacts with the amino groups of proteins and hence tends to cause a shift of the isoelectric point toward the acid side. Likewise, fixation with salts of heavy metals tends to shift the isoelectric point to the alkaline side by rendering the carboxyl groups non-dissociable (Baker, 1945; Dempsey and Wislocki, 1946; Kelly and Miller, 1935a). Thus the affinity of the proteins for basic or acidic stains will vary with the fixation.

In addition to the effects of fixatives on the staining qualities of proteins, those who use histochemical procedures that employ enzyme or acid hydrolytic action on nucleic acids should consider the possible effects of the fixatives on the bonding of the nucleic acid and nucleoproteins. The data concerning ribonuclease digestion techniques compiled by Stowell and Zorzoli (1947) and Lillie (1949) show that following a large number of fixatives enzymatic action results in a loss of basophilia while certain other fixations apparently render the tissues completely resistant to the action of the enzyme. Thus, in using the digesting-staining techniques, care should be taken to select a fixative which will not prevent the enzyme from hydrolyzing the nucleic acid.

Problems such as these arise from the fundamental complexity of the protoplasmic system. Obviously, in checking the validity of a cytochemical test, it is not sufficient to demonstrate that test-tube reactions between reagents and purified substances will occur, for in the cell many factors, difficult to control and usually not precisely known, may be involved in the reaction. This necessitates a continual guard against too great a confidence in any one procedure, along with never-ending effort to obtain a more complete understanding of the chemical and physical nature of the cell.

QUANTITATIVE TESTS

Although cytochemists have been chiefly concerned with the detection and location of the two types of nucleic acid, some attempts have been made to adapt the techniques previously discussed to permit quantitative measurements. Essentially the methods consist of using sensitive photoelectric cells to measure the amount of monochromatic light of a specific wave-length which is absorbed by the nucleic acid or by the dye-nucleic acid complex. The absolute extinction value is usually compared with a control measurement of the extinction in adjacent non-colored regions or by measuring the extinction in an area from which the nucleic acids have been removed by hot acid or enzymatic hydrolysis.

The ultraviolet absorption techniques developed by the Caspersson school have been most widely utilized for making quantitative determinations. Caspersson has emphasized the necessity for a rigid control of the physical conditions of the optical set-up (1940, 1947). He has also commented on the fact that the validity of the technique is dependent on the optical properties of the object measured (1947). Caspersson and all those others using this technique have assumed that the relation between the amount of light absorbed and the number of molecules of the substance follows the Beer-Lambert law. Commoner and Lipkin (1949) have shown that theoretically this law may not hold, if the nucleic acid molecules are oriented. Furthermore, Commoner (1949) has pointed out that nucleic acids organized in the form of a cell structure may be sufficiently oriented to cause significant departures from the Beer-Lambert law.

Procedures which measure the extinction of monochromatic visible light of appropriate wave lengths by structures colored by the Feulgen reaction or by basic staining have been devised by Stowell (1942, 1946b; Stowell and Cooper, 1945); by Pollister and Ris (1947), and Kurnick (1950b). The problem of molecular orientation just discussed is also present here. It is necessary for it to be demonstrated that the Beer-Lambert law holds in the specific preparation being analyzed. These techniques are also complicated by the difficulty of determining the number of reacting groups on the nucleic acid molecule which are involved in the dye binding.

CONCLUSION

The commonly used cytochemical techniques for studying nucleic acid, namely, the Feulgen reaction, basic staining, basic staining combined with enzymatic or acid hydrolysis, and ultraviolet absorption, have been discussed in terms of the criteria of a valid cytochemical test. The evidence indicates that under properly controlled conditions the tests are adequate for detecting and locating the nucleic acids in cytological preparations. Nevertheless, the complexity of the conditions under which the cytochemist works is such that it is necessary to maintain a critical attitude toward the procedures used and the conclusions drawn from the observations.

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DEVELOPMENT AND MEDUSA-BUD FORMATION IN THE HYDROMEDUSAE

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INTRODUCTION

THE Hydromedusae or Hydrozoa are usually conceived as coelenterate organisms alternating between a sessile hydroid phase which reproduces asexually to form medusae, and free-swimming medusae which reproduce by means of fertilized eggs, the eggs developing into planula larvae which settle and grow into hydroids. This is true enough of the majority of forms which constitute the Hydromedusae, and even of some of the Scyphomedusae. There has been a relative lack of emphasis upon the reproductive capacities of medusae as such, as distinct from their role in settling shallow water regions as hydroids and the production of new medusa swarms by those hydroids. This is undoubtedly a reflection of the comparative ease with which sessile hydroids can be studied from coastal laboratories, and the difficulties of investigating the activities of purely pelagic organisms.

The following review represents an effort to bring together what is known concerning the developmental cycles of medusae as they occur beyond the reach of shore or floor of the sea. The interest lies mainly in two activities, the development of medusa eggs directly into new medusae, and the processes of budding by the medusae themselves. Both of these refer to the maintenance of medusa populations within the ocean currents, drifting with the flow as far as it can carry them, until changing temperature or food supply puts an end to the migration. The hydroids, on the other hand, constitute a seedstock to windward. Four orders of the Hydromedusae are generally recognized, the Trachymedusae, Narcomedusae, Anthomedusae, and Leptomedusae, with some greater distinction being drawn between the two pairs than between the respective members of each pair. The adult taxonomy, however, does not concern us here, although it obviously has a large place in any adequate discussion of the question of the monophyletic or polyphyletic origin of medusae.

Development and budding are described in the following sections for each of the four orders separately, partly because the diversity and variability existing among and within them make a straight comparative account too complex, and partly to emphasize the parallelism that clearly exists between them.

Many of the accounts reviewed are old, accurate, detailed, and lost from contemporary literature. Others are recent, but in many ways, if we discount the interpretation of the times, the oldest are descriptively and illustratively the best; this refers especially to the monographs of Louis Agassiz, Metschnikoff, and not least, Alfred Goldsborough Mayer.

I. TRACHYMEDUSAE AND NARCOMEDUSAE

The size of the eggs of the Trachymedusae varies only within certain rather narrow limits, from the small egg of *Aglaura* of diameter 0.09 mm. to that of *Geryonia* with a diameter about three times as great. Even so, the volume difference is about thirtyfold. The size range for the eggs of the Trachymedusae is in fact much the same as that of the Scyphomedusae (cf. Berrill, 1949b), except that none appear to have as small an egg as that of *Haliclystus* and *Luncernaria* (0.03 mm. diameter).

In Fig. 1, the developmental stages of *Aglaura*, *Liriope*, and *Geryonia* are drawn to the same scale. *Liriope* and *Geryonia* may be the more directly compared. Even though the egg of *Geryonia* has twice the diameter and eight times the volume of *Liriope*, the cleavage and subsequent development of both are practically the same. In both, cleavage is total and equal, and the blastula is converted into a gastrula by delamination of the inner ends of all the cells to form an inner endodermal layer. A medusa develops directly in each case through continued and apparently uniform growth of the inner and outer spheres of cells. That is, with regard to the original polar axis of the egg, there is as much expansion in the transverse plane as along the polar axis. The planula-like nature of the larva which is formed from isolated 8-cell or 16-cell blastomeres may result from the reduced size of the cleaving mass, though it seems more likely to be caused by the essentially polar organization, which extends from the center to the periphery of the intact whole embryo and is dominant in isolated cells.

In any case, the direct development of the medusa of *Liriope* and *Geryonia* conforms well with the correlation shown for the Scyphomedusae with respect to egg size and its consequences. It is more difficult to account for the direct development in the case of *Aglaura*. The egg is not only remarkably small for one that undergoes direct development, but the epibolic overgrowth of the vegetal by the animal blastomeres represents an intense polar organization, in strong contrast to the preceding cases. The development of tentacles to form a small transient actinula stage in advance of the final elaboration of medusoid organization is strongly reminiscent of the narcomedusal type of development. In fact, there is more than a suggestion of heterogeneity within the Trachymedusae, and the sharp distinction between the medusoid orders based upon adult characters becomes progressively vague as the organisms become considered in their entirety in space and time.

Gonionemus (Fig. 2) has a small egg of a size typical of those which develop into planulae. In spite of the fact that the endoderm is formed by a regular delamination comparable to that of *Geryonia* and *Liriope*, the embryo elongates along its polar axis to form a planula, instead of developing directly to form a young medusa. The development of the egg of *Craspedacusta* (Fig. 3) is in general very similar, in so far as it is known, the main difference being in this case the more or less polar ingression of cells to form the endodermal mass.

In both *Gonionemus* and *Craspedacusta* a minute sessile polyp develops, one with tentacles and one without. In both cases a series of elongated buds are produced from the lateral body wall; they have acquired the rather unfortunate name of 'frustules.' They are essentially stolon-like outgrowths which become constricted off from the parent when about four or five times as long as they are wide. The epidermis and endodermis appear to be equally involved in their formation. A remarkably similar production of lateral elongated buds occurs during early stages in the life cycle of *Haliclystus* and *Lucernaria* among the Scyphomedusae (cf. Berrill, 1949b, c), and also in the Narcomedusae.

Under certain conditions, at least partly related to late growth and season, *Gonionemus* and *Craspedacusta* polyps produce buds which develop a medusoid organization before they are set free. In both forms the essential structure in this development is the formation of an entocodon (glockenkern, medusa-bell), something which is universally characteristic of medusa development throughout the orders Anthomedusae and Leptomedusae, but is absent in the Narcomedusae and the Scyphomedusae. The marine *Gonionemus* is the more typical in this respect. The two freshwater forms, *Limnocnida* and *Craspedacusta*, are remarkable in that the entocodon arises in the one as an open invagination of the distal epidermis of the medusa bud, and in the other by a process recognizably the same. This is in contrast to the origin of the entocodon in the Anthomedusae and Leptomedusae, an origin by delamination from a solid mass of tissue, of ectodermal origin in some, endodermal in others (Liu and Berrill, 1948).

Little is known concerning the early embryonic development of the Narcomedusae as a whole, and egg size and cleavage patterns are recorded only for *Solmaris* and *Solmundella*. A comparison of the early development of the trachymedusan *Aglaura* and *Liriope* with that of *Solmaris* is of some interest. In the case of *Aglaura* and of some eggs of *Solmaris*, the third or horizontal division is unequal, and the animal-pole cells overgrow the vegetal by a process of epiboly to form the two-layered gastrula. On the other hand, in the case of *Liriope* and of other eggs of *Solmaris*, the third cleavage is an equal one, and the gastrula in each of these is attained by central delamination of the inner ends of the cells of the blastula. It is probably incorrect to suppose that the difference in mode of endoderm formation is a consequence of inequality or equality at the third cleavage. It is more likely that inequality and epiboly are both expressions of a relatively intense polar organization of the cleaving egg. In spite of the extraordinarily large size of the egg of *Solmaris flavescens*, the largest recorded for any medusa, the eggs develop much as do the much smaller eggs of *Solmaris leucostyla*, exhibiting the same variability in cleavage and gastrulation. The experiments of Maas (1902), on 8- to 12-cell embryos showed definitely that a marked differentiation already exists at that stage along the polar axis.

The eggs of both *Solmaris* and *Solmundella* (Fig. 4) develop into medusae without passing through a sessile stage of any form. Whether cleavage has been equal or unequal, a planula-shaped embryo is produced before the medusoid form develops. In *Solmaris* one end of the embryo develops a bell margin and tentacle rudiments, not unlike the mode of development of *Aglaura*, and markedly different from that of *Liriope* and *Geryonia*. Both Brooks (1886) and Mayer (1910) regarded this type of development as one involving the transient formation of an actinula, that is, a non-attached hydra-like organism. The elongate planula-shaped larva of *Solmundella* is more difficult to interpret, for it is the central region which develops into the body of the medusa, and the two ends survive as the two tentacles of the adult. The limitation of the final tentacle number to two has undoubtedly impressed itself upon the course of early development.

The other Narcomedusae have a more complex developmental history, in part due to a parasitic phase, in part to an alternation of sexual and asexual methods of reproduction. It is not always clear which has been the origin of a particular medusa, but species of *Pegantha*, *Cunina*, and *Cunoctantha* (Figs. 4–6) do appear to have eggs which are modified in relation to the parasitic faculty. The eggs are in each case accompanied by a nurse cell that appears to nourish them during the early stages of cleavage, and the eggs at the time of fertilization are little if any larger than most kinds of tissue cells, that is, the usual size of oocytes before the onset of the growth phase.

Growth of course is necessary before anything approaching the medusoid or any other organization can be expressed, but the remarkable fact here is that such growth occurs after instead of before the onset of development of the egg. It is, however, only an assumption that the relatively minute size of the eggs (less than 10 microns diameter) is a secondary response to a form of parasitism. It is a possibility that should not be overlooked that we have here a survival of a primeval type of egg, a survival made possible only by the peculiarities of its special environment.

The primary embryo of these Narcomedusae may develop directly into a medusa, or by way of an actinula, parasitic on other medusae, which produces secondary medusae by means of aboral buds; or into a proliferating mass that subdivides, as for example in the polyembryony of certain bryozoans, to form numerous presumptive medusa buds. The variability of the budding site, as illustrated at least by the aboral budding stolon of *Cunoctantha octonaria* (Fig. 6), the external wall of the stomach pouches of *Cunoctantha fowleri*, and the inner lining of the gastric cavities of *Cunina peregrina* and *Pegantha clara*, suggests a multiple origin of the process. Aboral budding of actinulae and of immature medusae of *Cunoctantha* and *Cunina* may be homologous, the differences reflecting a temporal distinction, but the three sites referred to above appear to be basically distinct, and budding accordingly appears to be polyphyletic.

In all of the Narcomedusae known to produce medusae by budding, directly or indirectly, the process of budding is associated with the earlier developmental stages. Buds are produced the most rapidly in those forms in which they are produced soonest in the growth cycle as a whole, e.g., rapidly in internal budding, more slowly in juvenile stages, e.g., by actinulae, and more slowly again in immature medusae. The attainment of sexual maturity appears to follow the cessation of the budding activity. This should not be regarded as an incompatibility between the two types of reproduction, which in fact are not always disassociated, but as an inverse correlation. Budding is associated with active growth, occurs in direct proportion to the rate of growth, and ceases as growth slows to an end. Sexual maturity on the other hand develops with the attainment of near-maximum size or with cessation of growth.

While some Narcomedusae do not seem to have a parasitic phase in their life cycle, e.g., *Solmaris* and *Solmundella*, the majority of those of which the life cycle is known with some degree of completeness do have such a phase. It is a purely pelagic association, for the most part between medusa and medusa, and even when the host is an annelid it is the pelagic genus *Tomopteris*. Only in the case of the ubiquitous *Polypodium*, parasitic in the eggs of the sturgeon, do we have a benthic animal involved, and the incompleteness of this fantastic story leaves much to conjecture.

In a general way there seems to be a degree of specificity between parasite and host forms, but it is none too definite and may in part at least be due to propinquity of species in space and time. The parasitism itself appears in two forms. There is a more definite and obvious parasitism, such as that of *Cunoctantha octonaria* on *Turritopsis*, and the less tangible form where medusae develop free in the gastric cavities of the parental or some other medusa, in which they obtain nourishment from the liquid gastrovascular medium of the host.

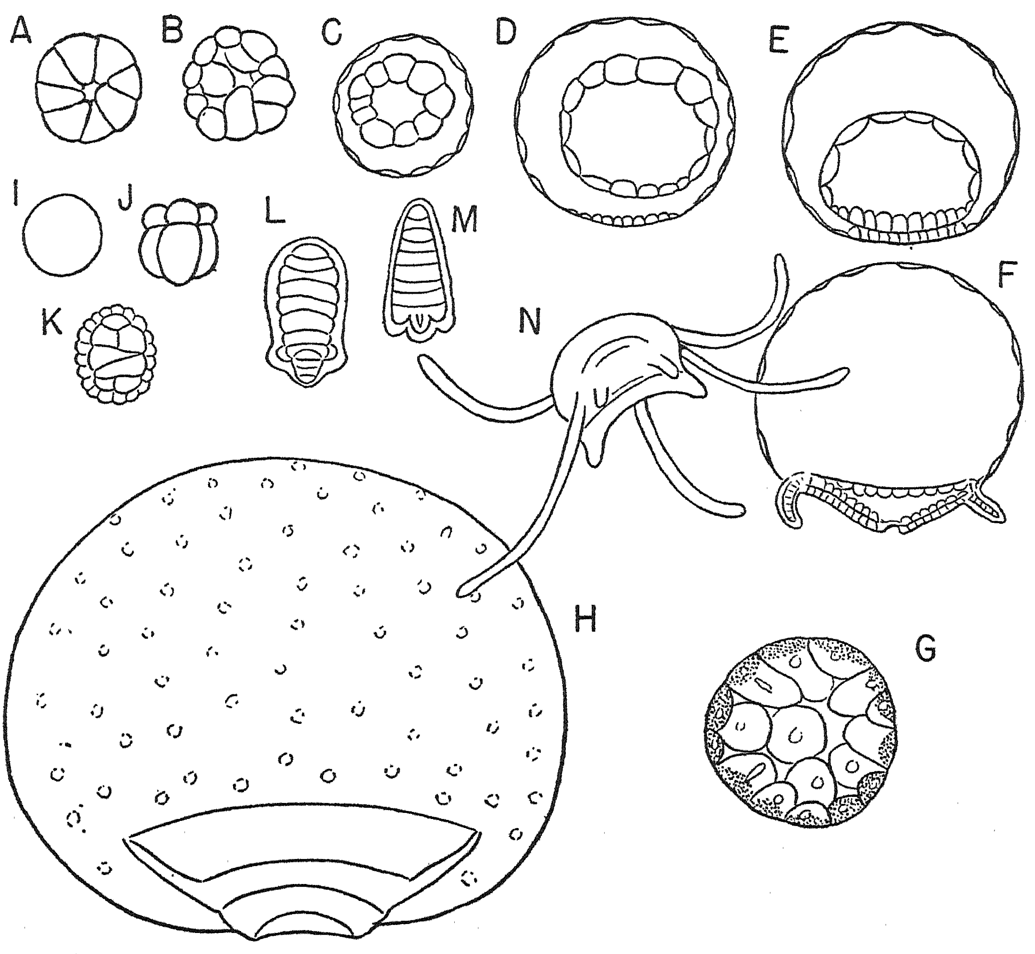

FIG. 1. DEVELOPMENT OF TRACHYMEDUSAE

Family Geryonidae: A–F, *Liriope mucronata;* G–H, *Geryonia proboscidalis.* Family Trachynemidae: I–N, *Aglaura hemistoma.* (After Metschnikoff.)

The developmental history of the trachymedusans and narcomedusans for which it is known is given below in more detail. In most cases there is a novel interest that does not lend itself well to a comparative account.

Trachymedusae

Aglaura hemistoma Peron and Lesueur (Fig. 1, I–N). According to Metschnikoff (1886), the comparatively small egg (0.09 mm. diam.) of *Aglaura hemistoma* develops in a semi-direct manner into a medusa. Cleavage is total but unequal, and the 8-cell stage consists of 4 micromeres and 4 macromeres. The larger cells become the endoderm and are enveloped by the micromeres through a form of epiboly, and a solid planula develops. The planula is elongated and the endodermal cells form a single row. The ciliated free-swimming larva develops tentacles. The first indication of this is a proliferative activity of endodermal cells in a transverse plane near one end of the planula, and a pair of tentacles emerges, followed by a second and intervening pair a little later. In fact, a small actinula or hydra-like form is produced, with 4 tentacles around a terminal manubrium and mouth (Fig. 1, M). Lithocyst clubs, which appear essentially to be modified tentacles, then grow out between the tentacles. The bell margin, that is, the swimming organ of the adult, appears last of all, as an outgrowth of the expanding rim between the bases of the tentacles and lithocyst clubs.

The development of the related form, *Rhopalenema velatum* Gegenbaur, which has the more usual egg size of 0.24 mm., is not known.

Among the Geryonidae, only the development of *Liriope* and *Geryonia* is known. Neither form has an egg exceptionally small or large. Their development is much alike, the only obvious difference between them being the production of six primary tentacles from the relatively larger embryo of *Geryonia*, compared with four in *Liriope*.

Liriope mucronata (Gegenbaur (Fig. 1, A–F) was studied by Metschnikoff (1886). The egg, diameter 0.135 mm., undergoes total and equal cleavage, while the innermost ends of the cells of the 16-cell stage delaminate to form the endoderm. Jelly is secreted between the two layers, the ectoderm becomes ciliated, and the embryo consequently swims. Continued secretion of jelly virtually forces the endodermal vesicle towards one pole of the ectodermal vesicle (Fig. 1, E, F). The mouth breaks through and four short tentacles appear. The velum is primarily an ectodermal outgrowth. Whether any stage in this process may legitimately be called an actinula is a matter of interpretation. Brooks (1886), working with the closely allied American species *Liriope scutigera* McCrady, found its development to be practically the same. Eight solid tentacles are formed, and according to Brooks the peristome in a sense pushes inwards to form the subumbrella.

Geryonia proboscidalis Eschscholtz (Fig. 1, G–H) has eggs which vary in diameter from 0.23 to 0.33 mm., the development of which has been studied by Fol (1873), Metschnikoff (1886), and Maas (1908). The general development is essentially similar to that of *Liriope*, and it is notable that there is the same delamination of the inner ends of the blastula cells of the 16-cell stage to form the endodermal vesicle. According to Maas, the undivided egg has a cortical layer of fine cytoplasm, an inner layer exhibiting a foam structure, and a central gelatinous region. This conforms well with the delaminating segregation (Fig. I, G). Maas also found that isolated 2-cell blastomeres give rise to perfect medusae, but that cells isolated at the 8- or 16-cell stage yield larvae much more like planulae.

It is notable that the whole egg of *Aglaura* has a volume less than an isolated blastomere of the 8- or 16-cell stage of *Geryonia*, and both its form of cleavage and epibolic manner of gastrulation indicate a polar organization more comparable with the isolated blastomere than with the whole egg of *Geryonia*.

Gonionemus (Fig. 2, A–L) and *Craspedacusta* Mayer, according to Perkins (1903), produce small eggs of about 0.07 mm. diameter (not 0.7 mm., as quoted by Mayer, 1910). Cleavage is total and equal and gives rise to a hollow ciliated blastula. The inner ends of all the blastula cells delaminate to form the endoderm, at a stage later than the 32-cell stage. Increase in size of the endodermal cells thus segregated results in the obliteration of the internal cavity. The larva elongates to form a free-swimming planula with one end broader than the other, the broad end becomes attached, mouth and tentacles appear at the opposite end, two at first, then a second pair. In this form it feeds and persists as a hydra (Fig. 2, D).

Buds are subsequently produced from near the base of the body wall of the attached polyp. A bud appears as a simple outgrowth involving both layers. Perkins found that the outgrowth of the bud up to the time of constriction occupied about 5 days, that there was a non-ciliated motile creeping phase of from 2 to 4 days, and that tentacles appeared 3 to 5 days after reattachment. According to Joseph (1925), while both epidermis and endodermis grow out to constitute the bud, active cell proliferation is more obvious in the epidermis of the young bud (Fig. 2, J). Joseph also described the formation of buds from all sides of the polyp base, and a succession of buds given off from each site.

Perkins was unable to observe the origin of medusae, but suspected a direct transformation of the polyp into a medusa. Joseph, however, found that medusa buds are produced from the body wall of the polyp at sites similar to those forming the planula-like buds, although apparently during the later growth phases of the polyp. The epidermis and endodermis both take part in this case also, but the terminal activity of the outgrowth appears to be different. Proliferation of the center of the distal end, especially of the epidermis, is much more intense, and it is fairly clear from Joseph's figures that a typical epidermal entocodon is produced as the initial stage in the formation of the medusa (Fig. 2, L). There is obviously no outward thrust of endodermis as in the first type of bud, and growth is relatively tangential.

Limnocnida tanganicae (Fig. 2, M–P) is another freshwater form, assigned to a family of its own among the Trachymedusae. In this case neither the development of the egg nor the nature of the hydroid is known. Medusa buds, however, are produced on the outer side of the rim of the stomach wall, involving both epidermis and endodermis. They pulsate before being set free. Sometimes budding stolons grow out. Gonads develop only after budding has ceased.

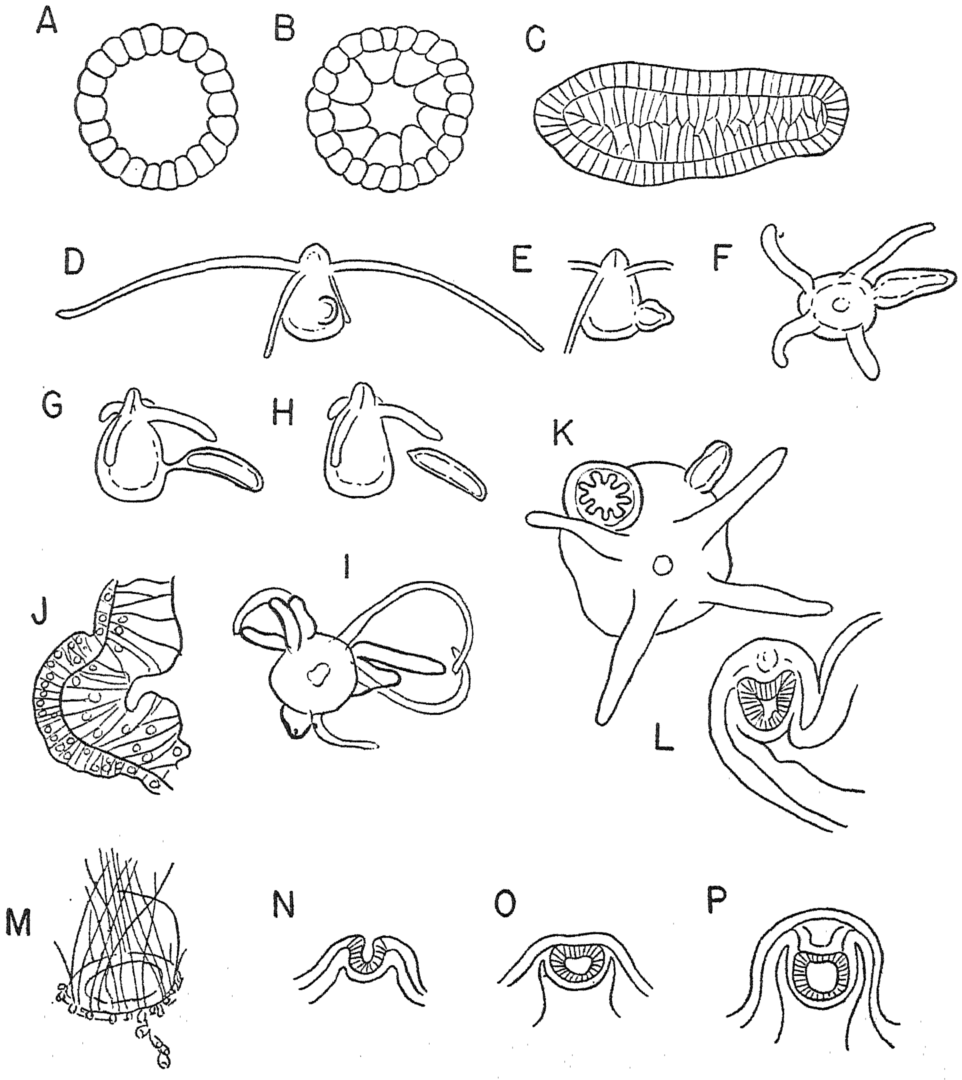

FIG. 2. DEVELOPMENT OF TRACHYMEDUSAE

Gonionemus murbachii (Olindiadae): A–C, segmentation, delamination, and panula; D, initiation of lateral bud; E, same one day later; F, four days later; G, H, another bud at a 15 minute interval; I, formation of multiple lateral buds from young hydranth; J, section through bud rudiment; K, older hydranth with both a lateral planula bud and a larger medusa bud; L, section through medusa bud showing advanced entocodon. (A–H, after Perkins; I–L, after Joseph.)

Limnocnida tanganyica (Limnocnididae): M, young medusa, showing marginal medusa buds; N, formation of entocodon by distal invagination; O, P, later stages in medusa formation. (After Boulenger.)

Medusa buds are formed in essentially the same way as in *Craspedacusta*, involving the formation of an entocodon and a typical subsequent development. The unique feature lies in the mode of de-modified tentacles, then grow out between the tentacles. The bell margin, that is, the swimming organ of the adult, appears last of all, as an outgrowth of the expanding rim between the bases of the tentacles and lithocyst clubs.

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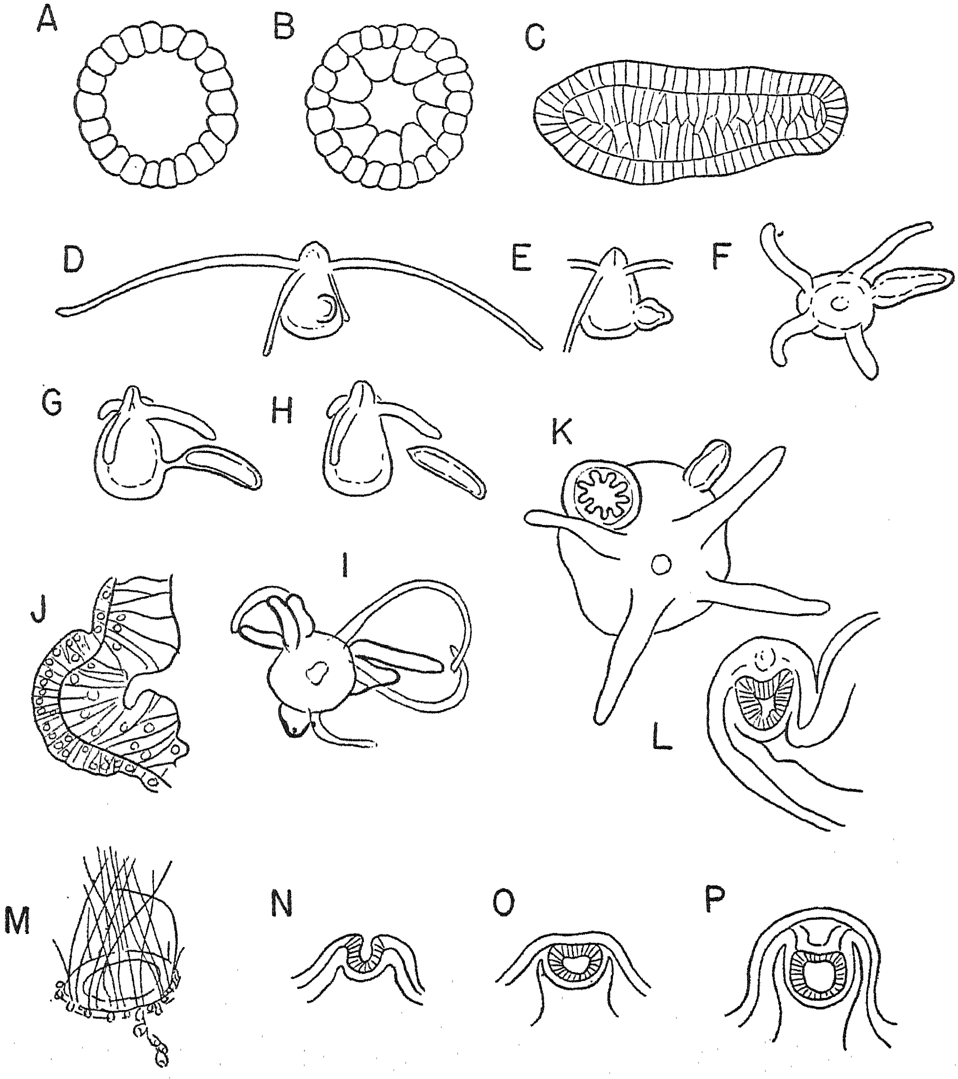

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Medusa buds are formed in essentially the same way as in *Craspedacusta*, involving the formation of an entocodon and a typical subsequent development. The unique feature lies in the mode of development of the entocodon itself. This structural unit is in any case the basis of the essential tetraradial organization of the medusa, but in all other cases it arises from a solid mass of distal epidermal tissue. In this instance (cf. Boulenger, 1911) the central distal region of the outgrowth actually invaginates, and the invagination subsequently constricts off as a subepidermal vesicle, the entocodon (Fig. 2, N, O, P). This is not necessarily the most primitive method, but in a developmental sense it is the simplest and most understandable. The procedure in *Craspedacusta*, however, is only a little removed, for while no open invagination is present, the invagination is discernible as a downgrowth from the distal center.

Craspedacusta sowerbii (Fig. 3), also a freshwater form, appears to be in many ways very similar to *Gonionemus*. The egg cleaves totally to form a hollow blastula and is converted into a planula by a broad ingression from one pole (Payne, 1926). The hydroid or polyp stage, originally call *Microhydra ryderi*, was long suspected to be the progenitor of the medusa *Craspedacusta*, and Payne (1924, 1926) finally followed through the complete life cycle. The polyp differs from that of *Gonionemus* in the absence of tentacles and in the

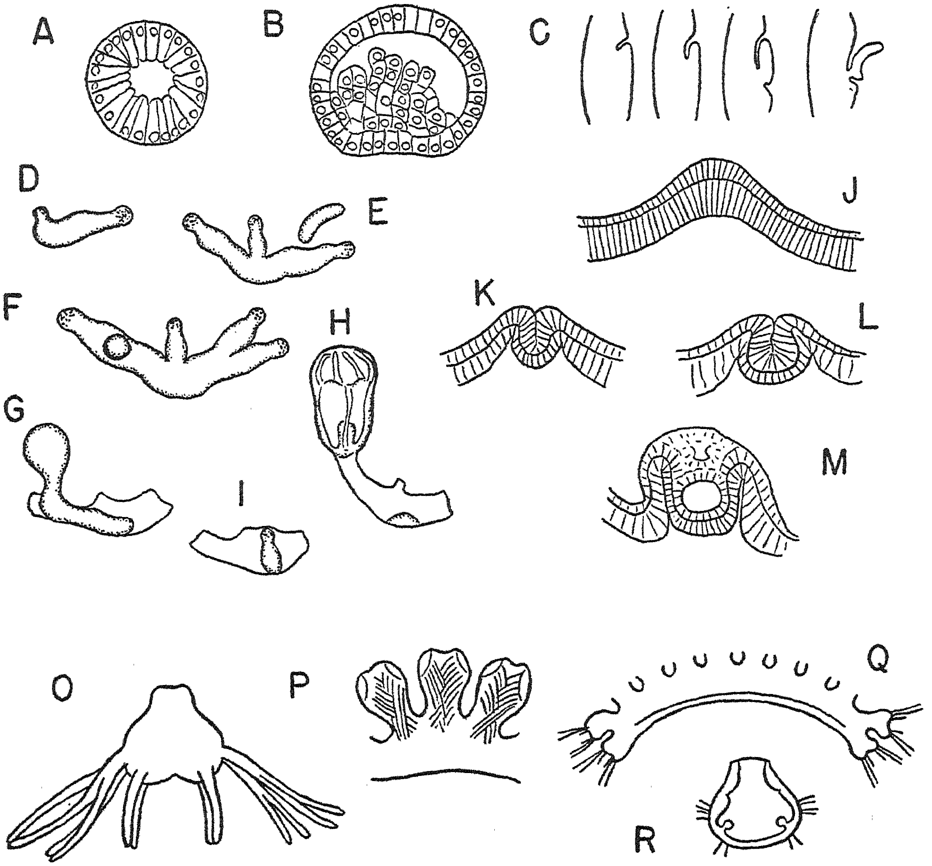

FIG. 3. DEVELOPMENT AND BUDDING IN THE TRACHYMEDUSAN CRASPEDACUSTA SOWERBII (A–M) AND THE NARCOMEDUSAN POLYPODIUM HYDRIFORME (O–R)

C. sowerbii: A, B, blastula and gastrulation; C, formation and separation of lateral bud from hydranth; D, 2-hydranth colony; E, 3-hydranth colony with lateral bud separated, three days later; F, same colony six weeks later with medusa bud; G, twelve days later, medusa bud advanced, hydranths resorbed; H, medusa bud complete, one day later; I, five days later, medusa liberated, remnant reorganized into new hydranth; J–M, initiation of medusa bud and formation of entocodon by virtual invagination. (After Payne.)

P. hydriforme: O, free polyp in walking position; P, part of budding stolon within a sturgeon egg, with three inverted polyps; O, stolon showing terminal polyps and bases of others, with basal split anticipating eversion; R, section through older polyp showing small gonads. (After Lipin.)

tendency of buds to remain attached together to form simple colonies. Buds are produced which are set free, however, and have the same capacity of non-ciliated migration. The manner of formation and segregation of the bud is somewhat distinctive, and consists of a more or less longitudinal constriction of the end from the long axis of the polyp (Fig. 3, C). The bud finally constricts off from the basal part of the polyp and is essentially like that of *Gonionemus*.

Medusa buds appear late in the growth season, and from the lateral wall, never by terminal transformation. Once initiated a bud continues to grow until development is complete, even at the expense of resorption of the feeding zooids (Fig. 3, F–H). Residual fragments of the colony tissue may reconstitute a polyp (Fig. 3, I). The outgrowth leading to the formation of a medusa bud consists of both epidermis and endodermis, as in the case of the other types of buds, but again as in *Gonionemus*, the central distal epidermal proliferation is much more intense than that of the adjacent endodermis, and the epidermis segregates as a typical entocodon, thereby initiating medusa organization (Fig. 3, J–M).

Narcomedusae

The Narcomedusae have lithocysts of endodermal origin like the Trachymedusae, but the ring canal is not well formed and is subject to great variability in development. There are two families, the Solmaridae, without stomach pouches, and the Aeginidae, with marginal pouches in the radii of the tentacles.

Two species of *Solmaris* have been studied. According to Metschnikoff (1886), *Solmaris leucostyla* Haeckel produces eggs with a diameter of 0.127 to 0.147 mm., which undergo total cleavage. Cleavage may be equal or unequal. Equal cleavage leads to the formation of a solid morula which delaminates centrally. In the case of unequal cleavage, a comparable result is obtained by epiboly.

Solmaris flavescens (Kölliker), according to Maas (1902), in spite of a large egg size varying from 0.8 to 1.5 mm. diameter, develops in the same way as *S. leucostyla*. The third or horizontal cleavage may be equal or unequal. In the case of equal cleavage, the inner ends of the morula cells delaminate, and an oval planula is formed. Jelly is secreted at the upper end between the two layers thus produced, separating the exumbrellar ectoderm from the subumbrellar endoderm. Tentacles grow out from the margin as wide basal bulbs. The bell margin itself grows beneath and between the tentacles, and the mouth finally breaks through.

Blastomeres isolated at the 2-cell stage form apparently normal planulae and medusae. The 8-cell stage, separated into small 4-celled animal and large 4-celled vegetal tiers of cells, gives rise to a small degenerate and a large, irregular embryo respectively. On the other hand, the 8- to 12-cell stage cut meridionally gives rise to more or less normal medusae. There is evidently a polar organization axis in the egg.

Solmundella bitentaculata var. *mediterranea* Haeckel (Fig. 4, O–S), also studied by Metschnikoff (1886), has eggs of diameter 0.23 mm. Cleavage is total and equal. After the 16-cell stage, endoderm is formed by a very general kind of multipolar ingression, with cells migrating from almost every point into the interior to fill it up. The larva then elongates, the ectoderm becomes ciliated, and the whole resembles a detached tentacle of some hydroid. The endodermal cells at both ends become disk-like and are set in a single row, with the two parts separated by a parenchymal central mass. The two ends form two tentacles, and the center forms the body of an actinula larva, which is at first mitre-shaped, with two long stiff tentacles. The mouth breaks through and a digestive cavity forms in the center of the parenchymal mass. Jelly forms above the digestive cavity between the two layers. The bell margin grows out from the sides of the larva *after* the actinula has been formed. While the early ciliated larva resembles a greatly elongated planula, this appearance seems to be the result of precocious tentacle formation, and the peculiar conformation is owing to the limitation of the final number of adult tentacles to two (Fig. 4, O–R).

Reproduction in two species of *Pegantha* has been described by Bigelow (1909). In *Pegantha smaragdina* H. B. Bigelow (Fig. 4, F–K), the eggs are of endodermal origin and develop in the exumbrella of the parent near the margin of the gastric cavity. Each egg is associated with an ameboid cell that divides amitotically. This is the nurse cell, and its importance is emphasized by the smallness of the egg itself. The egg, in fact, is almost unbelievably small, and while Bigelow did not give actual dimensions, his illustrations drawn to scale indicate a diameter of 7 or 8 microns, hardly larger than ordinary tissue cells (Fig. 4, F).

The egg cell divides completely and gives rise to

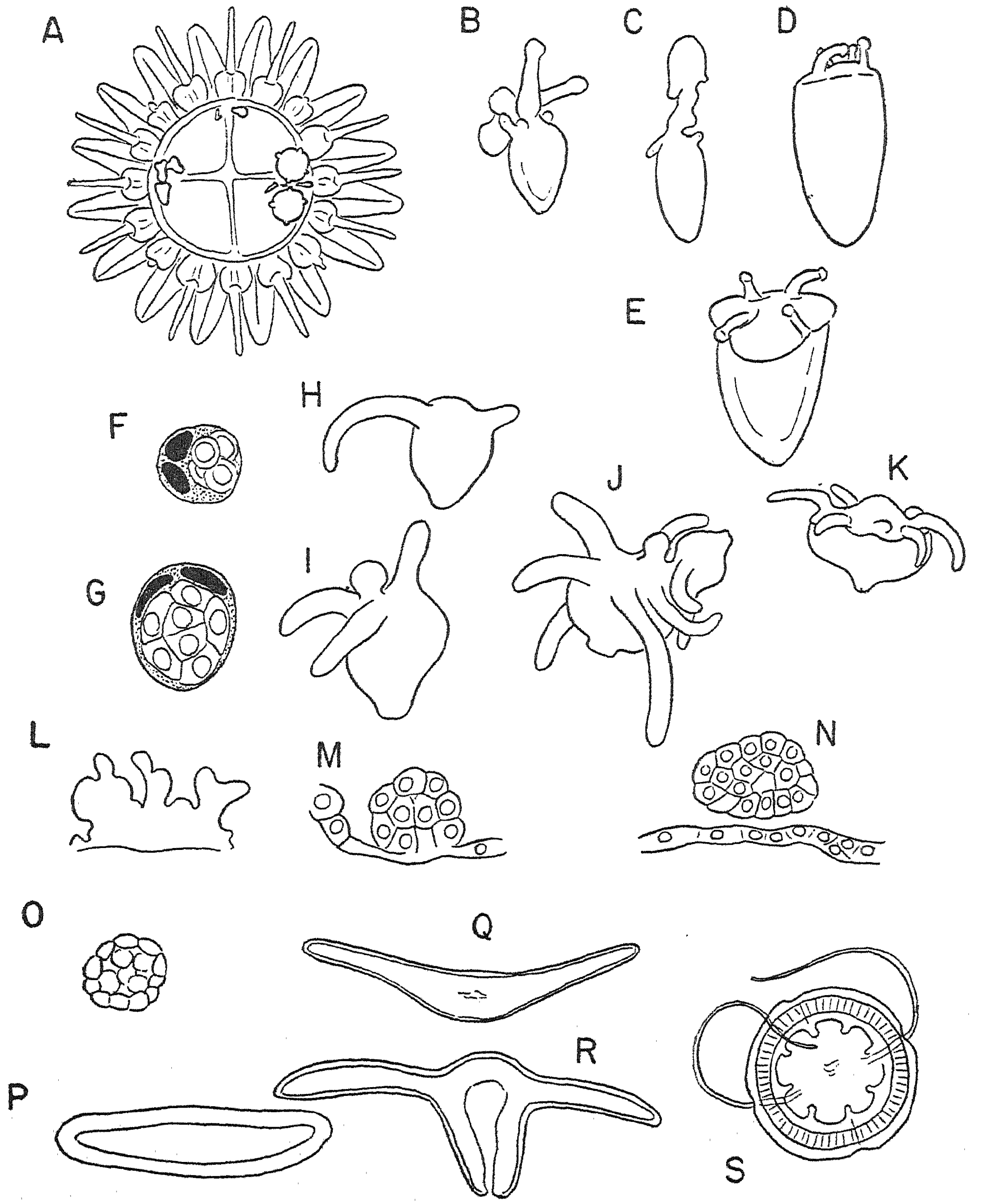

Fig. 4. Development of the Narcomedusae

Pegantha clara: A, medusa of *Periphylla* with polyps and medusae of *P. clara* in gastric cavity; B, primary polyp or actinula with tentacles and buds; C, bud becoming an actinula and producing a bud chain; D, E, transformation of actinula into medusa. (After Kramp.)

Pegantha smarygdina: F, 4-cell stage, together with nurse cell; G, 2-layered embryo with nurse cell; H, developing actinula; I, actinula with tentacles and bud; J, actinula with bud forming and with first bud in actinula stage; K, medusa ready for liberation. (After Bigelow.)

Pegantha laevis: L, M, N, proliferating mass, bud forming and bud set free, in internal budding from gastric lining. (After Bigelow.)

Solmundella bitentaculata: O, cleavage in egg; P, elongate embryo; Q, R, transformation of embryo into 2-tentacled larva and actinula, respectively; S, mature form. (O–R, after Metschnikoff; S, after Mayer.)

a solid morula (Fig. 4, G). As individual cell size is maintained, growth must accompany progressive cell division. The larva penetrates the endodermis and comes to lie in the parental gastric cavity, losing the nurse cell in the process. Larval endoderm is formed by secondary delamination, however, before the migration occurs. The planula-like embryo, about 30 microns long, develops into a more elongated larva with a chordate endoderm, similar to the tentacle-like larva of *Solmundella*. Its development is somewhat different, for a mouth appears at one end, and the bulk of the larva forms the primary tentacle, not the pair of tentacles as in *Solmundella*. A second tentacle develops opposite the first, and others in between at a later stage (Fig. 4, H).

When larvae have acquired four or more tentacles, they usually commence to bud, and at this stage are very numerous, lying in the canal system of the parent-host. Budding occurs at the aboral pole and involves both layers. A bud may separate from the parent larva while still a mere sac or remain attached until it in turn possesses tentacles and a mouth at its distal end. Only one or two buds are in process of formation at one time.

Buds thus produced develop or metamorphose into medusae. A bell margin appears as a ridge just oral to the tentacles, while flattening ensues, together with a progressive increase in the number of tentacles. Lithocysts are the last organs to appear, and then the medusae are set free from the parental cavities (Fig. 4, K).

In the second species, *Pegantha laevis* H. B. Bigelow (Fig. 4, L–N), Bigelow (1909) found a process of internal budding taking place from the endoderm of the peripheral canals, possibly from the ring canal alone. Only the endoderm is involved, and the proliferating ridges give off solid, ciliated, morula-like structures (Fig. 4, L–N). Whether they are liberated to develop independently, or whether they acquire some other host is not known.

Kramp (1947) found the larvae of *Pegantha clara* R. P. Bigelow (Fig. 4, A–E) to be floating parasites within the gastric cavity of *Periphylla periphylla* (Fig. 4, A). He distinguished two complexes of larvae in the youngest stages; one which differs in shape from the others he regarded as the primary larva, from which the others are produced by budding. When a bud attains a certain size, it becomes a free actinula with 2 and later 4 tentacles. A chain of actinula buds set free from the primary form may occur (Fig. 4, C); the actinula becomes medusoid by forming a circular collar just outside the tentacles. The medusae escape at about the time the mouth perforates.

The two remaining genera, the closely related *Cunina* and *Cunoctantha*, have been more widely studied. According to Bigelow (1909), internal budding similar to that of *Pegantha laevis* occurs in *Cunina peregrina* H. B. Bigelow (Fig. 5). In young individuals without gonads, ridges and thickenings develop on the oral surface of the gastric lobes. These are wholly of an endodermic nature, and proliferate to give off true buds. Buds at the time of constriction consist of about 24 cells and are set free into the parental gastric cavity (Fig. 5, A–C). Their later history is unknown but may be surmised in the light of what is known concerning other species of *Cunina*. In fact, Bigelow tentatively identified as *C. peregrina* a stolon found parasitically attached to the subumbrellar surface of a *Rhopalonema velatum*, together with some medusae recently detached from it. *Cunina* and *Cunoctantha* species are not self-parasitizing like *Pegantha*, but exploit other medusae, especially *Geryonia* and *Turritopsis*.

Cunina proboscidea Metschnikoff (Fig. 5, I–P) has been studied by Metschnikoff (1886), Woltereck (1905), Stschelkanowzew (1906), and by Hanitzsch (1921). According to Stschelkanowzew, there are three phases to the life cycle: the large, free-swimming, sexually mature *C. proboscidea* with 9 to 14 tentacles; a small 4-tentacled medusa, developed from an egg, attached to the stomach wall of the parent; and a budding stolon-like larva, either developed from an egg, attached to the stomach wall of the parent, or developed from the egg of the 4-tentacled medusa which becomes parasitic on *Geryonia*. Medusae asexually set free from the stolon become the large sexual *C. proboscidea*. The egg of the 4-tentacled parasitic medusa undergoes total and equal cleavage, associated with a nurse cell, to form a solid morula (Fig. 5, I–K). The endoderm is formed by delamination. Two pairs of tentacles are successively formed, after which the bell margin and velum grow out from the sides, and a mouth breaks through. The medusa is not set free, and with the subsequent growth of the gonads it degenerates into a mere sac.

Hanitzsch (1921) found the developmental cycle to be even more complex. He confirmed Metschnikoff that the egg is accompanied by a nurse cell. while sexually immature, constricts off a series of buds from a central dorsal stolon (Fig. 5, M, N),

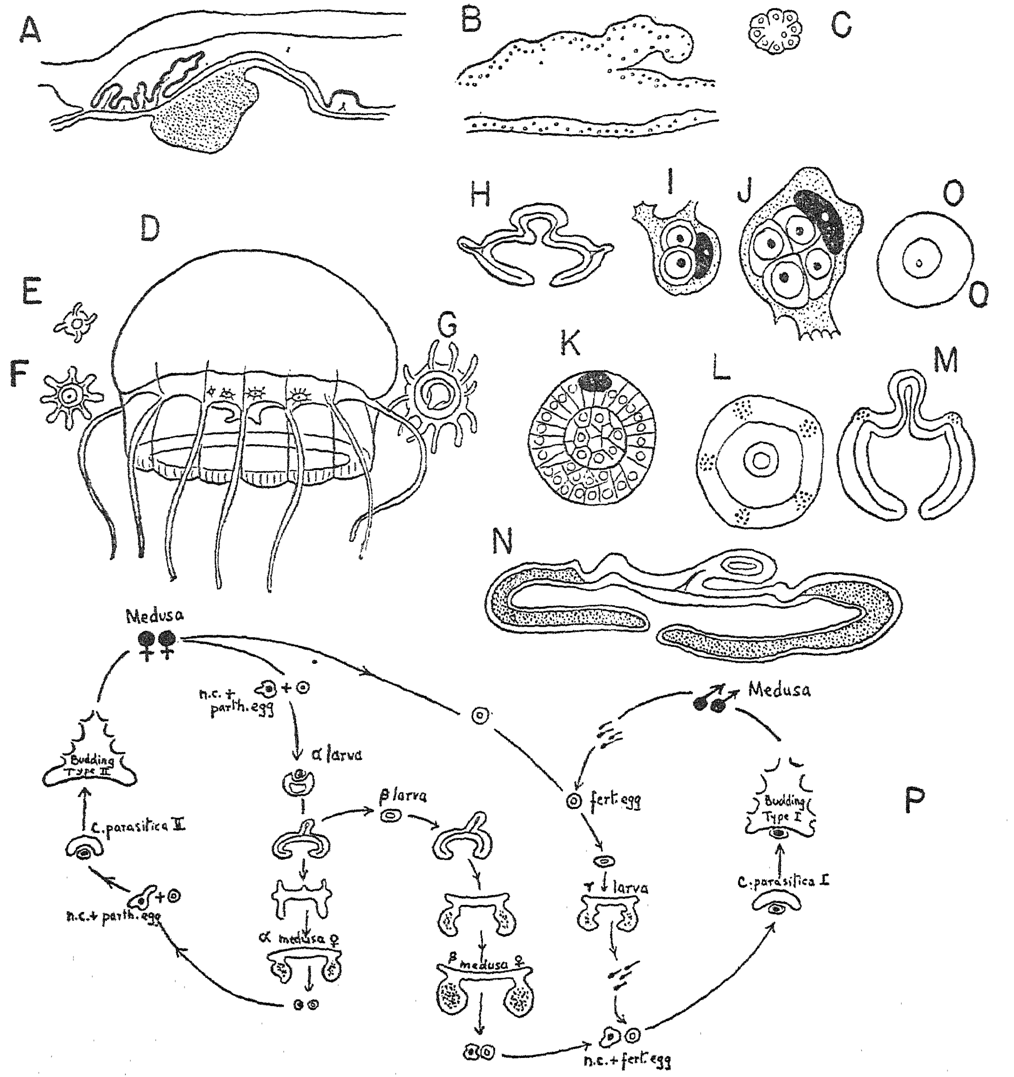

FIG. 5. DEVELOPMENT OF THE NARCOMEDUSAE: CUNINA

C. peregrina. A–C, internal budding. A, section through margin of medusa showing internal budding tissue in angle of gastric cavity, and gonad on outer, epidermal, surface; B, endodermal proliferating tissue with bud about to be set free; C, bud free in gastric cavity. (After Bigelow.)

C. prolifera. D, side view of mature medusa with first sexual generation within stomach cavity; E, F, G, successive stages in growth of sexual generation; H, median section of one of the same sexual medusae showing an aboral medusa bud. (After Mayer.)

C. proboscidea. I, J, 2- and 4-cell stages with nurse cells in parasitic generation; K, 2-layered embryo; L, M, dorsal and side view of first sexual medusa form with aboral medusa bud; N, section through first sexual medusoid form with aboral budding stolon; O, egg of first sexual form; P, diagram of semi-hypothetical life cycle of *C. proboscidea. n.c.*, (I–M, O, after Metschnikoff; N, P, after Hanitzsch.)

The egg may be fertilized, in which case it gives rise to a small γ male medusa. Or it may develop parthenogenetically into a so-called α-larva. This, then ceases to do so and continues to grow into a dwarfed female medusa. The buds formed in the process develop into β-larvae, each with a similar budding stolon, and then grow into dwarfed female medusae. Fertilized eggs from the products of dwarfed γ male medusae and β-female medusae yield budding stolon larvae of type I, the buds of which develop into large male medusae. Parthenogenetically developing eggs of dwarfed α-female medusae produce budding stolon larvae of type II, the buds of which form large female medusae. The cycle is shown diagrammatically in Fig. 5, P. The stolon larvae of types I and II are liberated from the parent forms and become parasitic within *Geryonia.*

Cunina prolifera Gegenbaur has a cycle essentially the same as that of *C. proboscidea* (Stschelkanowzew, 1906). The aboral buds produced by the medusae attached to the stomach wall of the parent host (Fig. 5, D–H) are formed in a pattern distinct from those of *C. proboscidea* (Hanitzsch, 1921).

Several species of *Cunoctantha* have been investigated (Fig. 6). The cycle of *Cunoctantha octonaria* Haeckel has been studied by Brooks (1886) and Wilson (1887). The earliest stages are unknown. A two-layered ciliated planula-like larva attaches itself by its mouth to the bell margin of *Turritopsis nutricula* McCrady. The cilia disappear and two pairs of tentacles appear successively at the aboral pole. The larva then enters the bell cavity of the host and clings to the wall of the subumbrella (Fig. 6, A). A long throat-tube is then developed and inserted into the mouth of *Turritopsis*, and the larva becomes therefore a parasitic actinula.

Other and similar larvae, which are budded off from the aboral pole between the tentacles, develop like the primary larvae (Fig. 6, B). They continue development, however, to become medusae. The bell or umbrella appears as four lobes between the four tentacles (Fig. 6, D), after which four new tentacles appear and the velum grows between the lobes.

According to Metschnikoff (1886), Mayer (1901), and Woltereck (1905), the cycle of *Cunina parasitica* Metschnikoff is essentially the same. *Geryonia proboscidalis* is parasitized in place of *Turritopsis*, while the parasitic budding larva gives rise to true medusa buds upon its sides. Each such bud is a simple evagination of ectoderm and endoderm. The mouth breaks through and then eight bell lappets and eight tentacles are formed simultaneously. Jelly is secreted by the endoderm, and eight radial stomach pouches are formed by local flattenings of the polyp-shaped buds.

Another narcomedusan larva, probably that of *Cunina lativentris* Gegenbaur has been reported by Damas (1936) to be parasitic in the cavity of parapodia of the pelagic polychaete *Tomopteris nisseri*, where it buds and increases enormously in number, until the host becomes castrated. Increase in number is first accomplished by a kind of polyembryonic fission of the morula (Fig. 6, M, N). Later, budding takes place at the aboral end of the actinula, and continues even after the medusoid condition has been reached (Fig. 6, R, S).

The cycle of *Cunoctantha fowleri* Browne is not fully known, but Browne and Fowler (1906) described medusa buds, *not* parasites, developing from the eight stomach pouches. Both the ectoderm and endoderm of each pouch contribute, and the buds project into the bell cavity. The mouth tube is formed before the tentacles and bell lappets. These buds were seen only in young nonsexual forms (Fig. 6, G).

The remaining narcomedusan whose cycle is known at least in part is the peculiar form *Polypodium hydriforme* (Fig. 3, O–R). It has been described at length by Lipin (1911). The budding stolon occurs as an internal parasite within the eggs of the sturgeon. Sturgeons on the spawning run in the Volga, opened before the eggs have been laid, usually are found with some eggs infected. Moreover, the condition of the hydroid indicates a considerable preceding history. Nothing whatever is known of the way in which the eggs become infected, nor is the sexually mature form of *Polypodium* known.

Within the sturgeon's egg the hydroid stolon is coiled spirally and is everted so that the endodermis is external and in contact with the surrounding yolk of the egg, while the epidermis faces inwards on to a closed cavity. Buds evolve as a series of bulges from the stolon outward into the yolk (Fig. 3, P). Tentacles grow inward from the epidermis into the central lumen, and each bud develops twelve tentacles. At the time of spawning of the sturgeon, the basal part of the stolon splits along its length, the whole becomes everted, including the attached polyps, so that epidermis and endodermis acquire their proper status (Fig. 3, Q). In the eversion process, each bud mechanically includes a mass of yolk in its basal region, and when the bud is set free from the egg and the stolon as a whole, it is consequently supplied with sturgeon yolk for continued growth. No mouth is formed, at least at this time. The liberated polyp

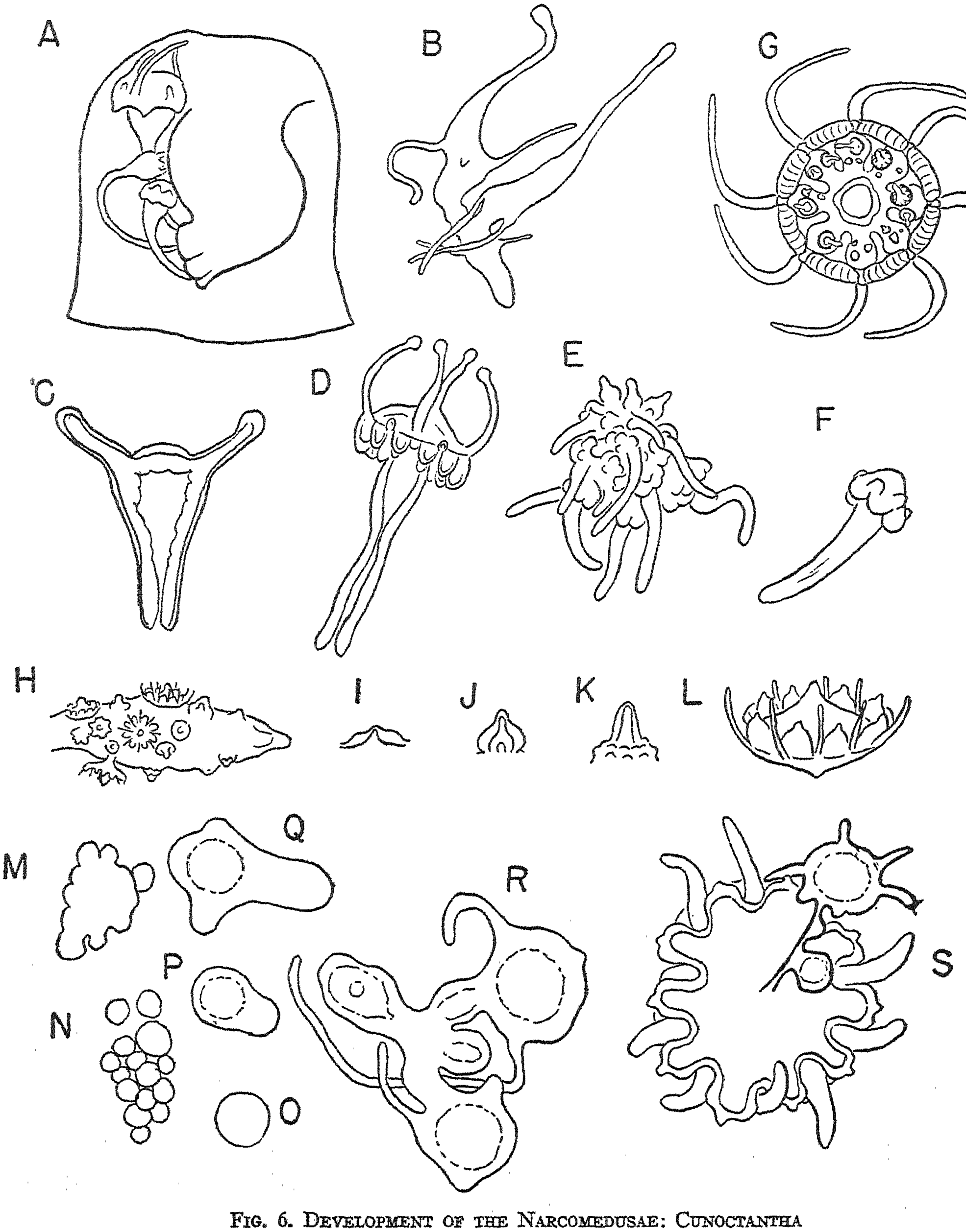

Fig. 6. Development of the Narcomedusae: Cunoctantha

C. octonaria. A, actinulae, attached to the manubrial lips of *Turritopsis nutricula;* B, budding of actinula; C, D, development of actinula into medusoid stage; E, F, stolon larva giving rise to numerous actinulae, and development of medusoid bell margin in actinula. (A–D, after Brooks; E, F, after Bigelow.)

Cunoctantha fowleri. G, medusa, showing medusae being budded from wall of gastric pouches. (After Browne.)

C. octonaria var. *kollikeri.* H, a stolon larva, probably of this form, budding medusae from its surface; I–L, stages in development of the medusa buds. (H–L, after Mayer.)

Cunina lativentris. M–R, budding and development within a parapodium of *Tomopteris;* M, N, proliferation of initial budding mass; O, P, Q, growth of actinula from individual bud; R, budding of actinula and onset of medusoid structure; S, budding of medusae from medusa. (M–S, after Damas.)

(Fig. 3, O) walks around on the river bottom by means of its tentacles (of which there are two kinds). Growth continues and is expressed in two ways. Tentacles increase in number to 24, while the polyp divides medianly to give rise to two individuals, each with 12 tentacles. The process continues until polyps with 12 tentacles are found dividing into two polyps each with 6 tentacles. These reconstitute polyps with 12 tentacles, and in fact several months after the sturgeon eggs are laid, free *Polypodium* polyps are to be found with 12 or 24 tentacles, and none with 6. It appears to be primarily a question whether or not a polyp first divides in a physical or organizational sense.

What is known of *Polypodium* is fantastic enough; what is left to be discovered cannot be less. Lipin (1926) has described free polyps with immature gonads (Fig. 3, R). These gonads are in themselves peculiar, being closed sacs with contained ovaries connected with the external base of the sac by an *oviduct*. The location of these sacs within the body of the *Polypodium* suggests that this is itself a modified medusa, and there may or may not be a better developed medusa included in the life cycle. Lipin attempted, not very convincingly, to show that *Polypodium* is a reduced type of the Coronatae among the Scyphomedusae.

II. ANTHOMEDUSAE AND LEPTOMEDUSAE

Among the Anthomedusae taken as a whole, though excluding the hydroid phases, medusa buds are produced at three sites, from tentacle bulbs, from the wall of the manubrium, and from the wall of the radial canals. Manubrial budding occurs in *Slabberia*, *Sarsia*, and *Eucodonium* among the Codonidae, and in *Podocoryne*, *Rathkea*, *Bougainvillia*, and *Cytaeis* among the Oceanidae. The production of medusa buds from the central regions of the radial canals may possibly be homologized with manubrial budding. Leaving this type aside, however, the conclusion seems inescapable that budding has been acquired on several occasions by this group of medusae.

In all cases, the production of buds is associated with a region of relatively high growth rate, that is, with a relatively elongating manubrium, as in *Sarsia* and *Slabberia*, or with regions of local growth, as in the case of tentacle bulbs, or with regions associated with the later production of gonads, as in the manubrial budding of the Oceanidae and from the radial canals in *Proboscidactyla*. In young juvenile forms, with a relatively high rate of growth in general, the presumptive gonadal tissues proliferate cell masses which develop into medusae asexually. As the general growth rate slows down, bud formation ceases and the gonads differentiate. The two processes may overlap somewhat in time, as in *Hybocodon*. Germ cells and bud rudiments do not always form from the same layer of tissue, but when they do, as in *Rathkea*, it is evidently a case of divergent differentiation from an essentially indifferent totipotent tissue.

The sequence of bud formation, often called the law of Chun, is primarily a matter of space becoming available for the initiation of buds in a progressive manner. A bud rudiment needs a certain minimum area available for its initial establishment. As such areas emerge in a budding region as a result of a general tissue growth, bud rudiments become successively initiated. In very small forms, such as *Podocoryne*, a girdle of three or four medusae develop around the manubrium, appearing successively in time (Fig. 8, A, B). In the larger medusae of *Bougainvillia*, between twenty and thirty may be developing at the same time (Fig. 8, E), although each medusa bud of a certain stage is approximately the same size as similar stages in *Podocoryne*. In the much larger medusa of *Cytaeis* (Fig. 8, I), the individual medusa bud, for a given stage, is no larger, but over a hundred buds may be developing at one time from the extensive manubrial surface. The tendency for buds to develop along a helical line on the manubrium is mainly due to progressive distal growth of the manubrium and the successive manner in which available areas for bud initiation become delimited around the manubrial circumference.

The type of budding exhibited by *Niobia* (Fig. 9) involves phenomena of a more subtle nature. While in this case budding is essentially a tentacle bulb activity, it is mainly a growth of the whole bulb and its progressive development of an independent medusoid organization, as its progressively increasing size permits. This developmental or reconstitutional reaction to local growth comes within the category of C. M. Child's "physiological isolation," but it does not enlighten that enigmatical phrase.

It is also significant that budding in these anthomedusan medusae is primarily an activity of juvenile forms still in relatively rapid growth, and that in *Niobia* as in others, sexual maturity succeeds the budding and growth phase. It is also of particular interest that when budding does extend through into the sexually mature phase, as in *Hybocodon*, the buds exhibit a sexual maturity comparable with that of the parent form, suggesting a possible correlation of gonad differentiation with a specific growth rate in the double parent-bud organism (Fig. 7, O).

In two of the largest families of the Leptomedusae, namely, the Plumulariidae and Sertulariidae, free medusae no longer exist, and the gonophores are reduced to sessile sporosacs. Free medusae are produced within the Campanulinidae and the Campanulariidae, although in both of these families reduction of the gonophores to sporosacs has also occurred in a number of cases. Within this order, the production of medusa buds by the free medusae is accordingly relatively rare, but the few known cases are of considerable interest, especially when we compare the production of medusae by medusae with the production of similar medusae by the respective hydroids.

In the Campanulinidae, medusae develop from the hydroid as terminal developments from independent outgrowths, for example, in *Campanulina* (Fig. 10, F), much as in the Anthomedusae. Medusa buds formed by a free medusa, as in *Euchilota* (Fig. 10, G), develop as direct outgrowths in a comparable manner. In this case they form from the outer wall of the radial canals, somewhat as in the anthomedusan *Proboscidactyla*, coinciding in position, though not in time, with the gonadal region. Gonads differentiate after budding has ceased.

Among the Campanulariidae the case of *Phialidium mccradyi* is outstanding. Medusa buds are produced in large numbers by the free medusa, as well as by the fixed hydroid. The significant fact is that, whether hydroid or medusa, medusa buds are formed in only one way, as outgrowths of the blastostyle of a gonangium. This is the method which is universal within the family, by which the hydroids produce medusae. In the only free medusa known to produce medusa buds, the procedure is identical. It is also notable that the gonangia formed by the medusa are produced at the site of the gonads, but at an earlier phase preceding sexual differentiation.

The third case, *Gastroblasta*, probably also a campanularian, raises the same general problem as *Niobia*, why an organism which continues to grow more along one axis than another should reconstitute itself into two similar organisms.

Anthomedusae

The Anthomedusae (-Gymnoblastea) are reviewed here primarily as medusae capable of budding off other medusae asexually. The diversity of reproductive behavior among the hydroid phase of the various forms is too great to be encompassed in the present account, and merits separate discussion. Medusa budding is described below under the heading of major families, in order to emphasize the polyphyletic nature of the process. Of those included, the genera *Sarsia* (-*Syncoryne*), *Hybocodon*, *Eucodonium*, *Slabberia*, *Margelopsis*, and *Pelagohydra* all belong to the family Codonidae. *Podocoryne*, *Cytaeis*, *Bougainvillia*, *Rathkea* (-*Lizzia*), *Proboscidactyla*, and *Niobia* belong to the Oceanidae. *Cladonema* and *Eleutheria* are members of the Cladonemidae.

Codonidae

The genus *Sarsia* is one of the more interesting, for among its species it includes a number which do not produce buds at all, one that produces medusa buds in series from the base of each of its four tentacles (*Sarsia prolifera*, Fig. 7, A), and one that produces medusa buds along the length of an elongating manubrium (*Sarsia gemmifera*, Fig. 7, B, C). Thus one species of *Sarsia* produces manubrial buds in a manner strictly comparable with *Slabberia catenata* (Fig. 7, E, F), and another with the type of budding from the base of the tentacle characteristic of *Hybocodon prolifer* (Fig. 7, I). *Eucodonium*, on the other hand, develops medusa buds from a manubrium in a way more like that of the Oceanidae (Fig. 7, H).

Both *Sarsia gemmifera* Forbes and *Slabberia catenata* Forbes and Goodsir have been investigated by Chun (1896), and in spite of the adult medusae being assigned to separate genera they exhibit a remarkable similarity in the manner of budding. Inasmuch as the hydroid of *Slabberia catenata* is, like those of *Sarsia*, a *Syncoryne*, the relationship may actually be a very close one. A hydroid of *Syncoryne eximia* (Fig. 7, D) is given as an illus-

(FIG. 7—*Continued*)

S. catenata. G, non-budding individual with manubrial gonad. (After Mayer.)

Eucodonium brownei. H, manubrial medusa buds. (After Mayer.)

Hybocodon prolifer. I, medusa buds developing from single, divided tentacle base and from tentacle base of advanced bud. (After Mayer.) O, Sexually mature medusa producing mature bud. (After Hartlaub.) P, assymmetrical growth and budding of tentacle bulb. (After Brooks.)

Margelopsis haeckelii. J, K, actinulae growing from manubrium, and free, pelagic, actinula of same with medusa buds between tentacle rings. (After Hartlaub.)

Coryne tubulosa. L, hydroid budding off a free hydranth; M, a free pelagic hydranth with young medusa bud. (After Rees.)

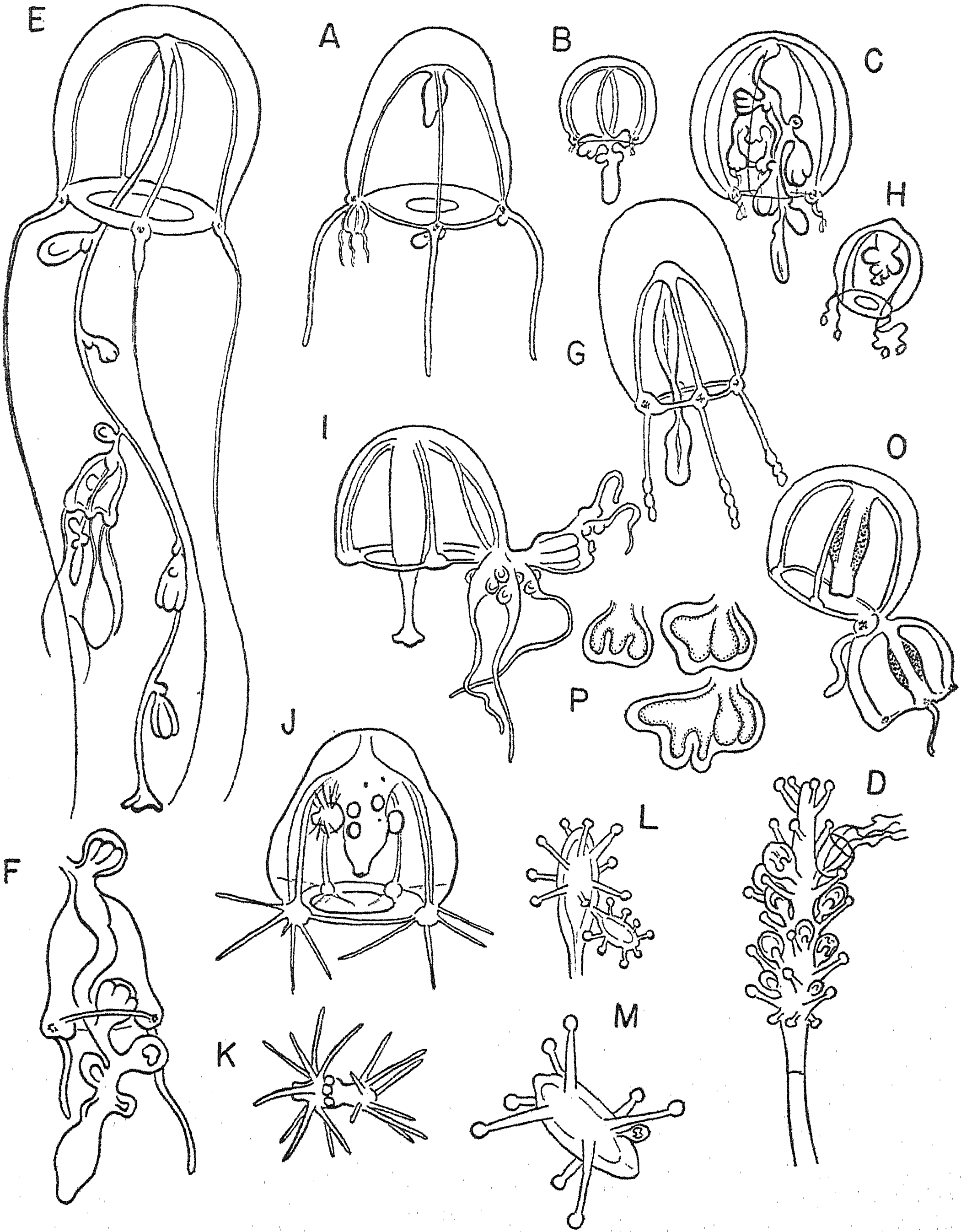

FIG. 7. BUDDING IN THE ANTHOMEDUSAE, FAMILY CODONIDAE

Sarsia prolifera. A, medusa buds forming from base of tentacles. (After Mayer.)

Sarsia gemmifera. B, C, young medusa with medusa buds developing from an extending manubrium. (After Chun.)

Sarsia (= *Syncoryne*) *eximia.* D, hydroid, with medusae forming between the tentacles. (After Allman.)

Slabberia catenata. E, long manubrium bearing medusa buds; F, advanced medusa bud of same bearing younger bud on stalk and series of buds on its own manubrium. (After Chun.)

(*Continued on p. 306*)

tration, even though the species as a medusa is a non-budding form.

Hybocodon prolifer L. Agassiz is a form remarkable in many ways. It was beautifully illustrated and described as a dynamic organism by Louis Agassiz (1862). The medusa differs from *Sarsia* in having three out of four tentacles abortive, and the fourth a well developed cluster (Fig. 7, I). Medusa buds form from the sides of the tentacle bulbs of the cluster. These buds in turn develop a large tentacle even before being set free, and from the base of this, medusa buds of the next generation may be discernible before the parent medusa is liberated. It is interesting to compare the process of medusa-budding as described by Agassiz for the youngest medusae (Fig. 7, P), still attached to the parental hydranth, with the condition illustrated by Mayer (1910) for the free miniature medusa (Fig. 7, I), and that by Hartlaub (1933) for medusae already showing evidence of approaching sexual maturity (Fig. 7, O). Perkins had earlier reported simultaneous sexual and asexual reproduction, medusae still developing from the tentacle bulbs while actinulae, derived from eggs, grew attached to the side of the manubrium.

According to the description of medusa-bud formation given by Agassiz for those attached to the hydroid, the primary outgrowth, consisting of both endoderm and ectoderm, grows at an unequal rate in its two transverse planes, and at a very early stage in development the body wall at the side of one of the four radial tubes grows out until the diameter of the bud as a whole is about twice as great in one axis as the other. A second lateral outgrowth, and then a third and a fourth, appear successively in the same plane and direction long before the liberation of the primary medusae, so that many generations may be seen in formation at the same time (Fig. 7, P).

In the free-swimming but sexually immature medusae, the differential is much reduced and usually but two or three bud generations at the most are found coexisting. Finally, as sexual maturity is reached, asexual budding may cease, or at least is reduced in rate, so that usually a single relatively large medusa bud is found developing from the tentacle base. In such cases, even the bud itself may show evidence of sexual maturity, and it seems likely that the last bud to be liberated may pass directly into a condition of sexual maturity without exhibiting either a preliminary or coexisting phase of asexual reproduction. While the exact size of *Hybocodon* eggs has not been recorded, Uchida (1927) described them as being very large, only two or three developing at one time. These large eggs give rise to actinulae, and the relationship to *Tubularia* is again emphasized.

In *Margelopsis haeckeli* the eggs are also few and large, and actinula larvae develop attached to the manubrium (Fig. 7, J). These are finally set free, and have two rings of tentacles. In this condition they are typically pelagic. Medusa buds develop as a ring in the zone between the tentacles (Fig. 7, K) and are eventually liberated (Hartlaub, 1933). The actinula larvae in these forms and tubularians are essentially hydranth heads, and the budding of medusae in this case is typical of the budding from sessile hydranths, only the stalk is not developed.

In *Coryne tubulosa*, according to Rees (1941), the sessile colony may be a creeping form, the stems of which bear single hydranths, many of which were found to be producing medusa buds. At the same time some of the hydranths produced buds that grew to form hydranth rather than medusoid organization (Fig. 7, L). These buds were liberated as free hydranths like those of *Margelopsis*, and were capable of producing medusa buds in turn (Fig. 7, M).

Climacodon ikarii appears to be also similar to *Margelopsis*, and produces stemless hydroids that are adapted for pelagic life and develop medusa buds (Uchida, 1927). The peculiar form *Pelagohydra mirabilis*, with tentacles and medusa buds arising irregularly from the surface of the pelagic hydranth, belongs to the same group (Dendy, 1913).

Oceanidae

Many of the medusae of the Oceanidae likewise produce medusa buds asexually. The majority develop buds from the sides of the manubrium. This is the case for *Podocoryne fulgurans*, in which, according to Mayer (1910), they appear in series in a close helix. *Podocoryne minuta* also produces manubrial buds, and Mayer states them to be purely of ectodermal origin. Manubrial buds are also characteristic of *Bougainvillia frondosa*, *Bougainvillia niobe*, *Cytaeis atlantica*, and *Rathkea octopunctata* (Fig. 8, A–I). The helical arrangement of the budding series is again evident in *Rathkea* and was emphasized for this form by Chun (1896). He also demonstrated that both the ectoderm and endoderm of the buds are of manubrial ectodermal origin. It may be seen from Fig. 8, D, E, and I, that the number of buds developing at the same time from the manubrium of the three forms illustrated varies greatly. If, however, the three figures were shown at the same scale, it would be seen that the young buds were of much the same size and that the variable is in the size of the budding manubrium; the larger the budding area, the more numerous the buds. All of the forms recorded as producing medusa buds asexually are comparatively small and miniature, and the attainment of sexual maturity occurs some time after the cessa-

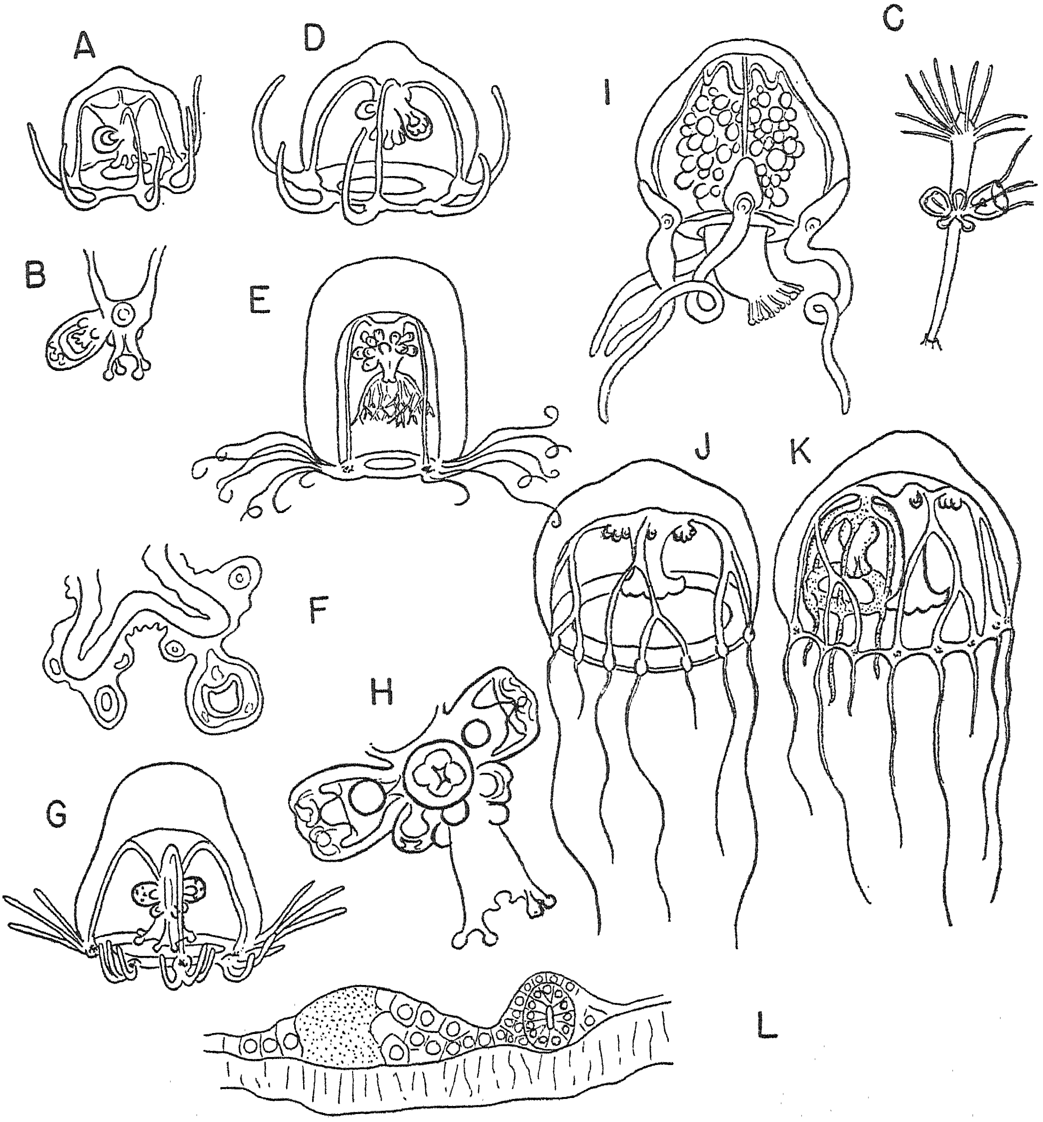

Fig. 8. Budding in the Anthomedusae, Family Oceanidae

Budding of medusae from the manubrium or the radial canals.

Podocoryne fulgans. A, young medusa; B, enlarged view of manubrium. (After Mayer.)

Podocoryne cornea. C, hydroid. (After Hincks.)

Bougainvillia frondosa and B. niobe. D, E, with manubrial buds; F, section through manubrium of *B. niobe* to show ectodermal origin of the buds. (After Mayer.)

Rathkea octopunctata. G, medusa; H, manubrium showing spiral sequence of buds. (G, after Mayer; H, Chun.)

Cytaeis atlantica. I, with very numerous manubrial buds. (After Haeckel.)

Proboscidactyla ornata var. *gemmifera.* J, K, multiple medusa buds arising at junction of the 4 radial canals with the stomach wall. (After Mayer.)

tion of budding. The gonads also develop from the manubrium.

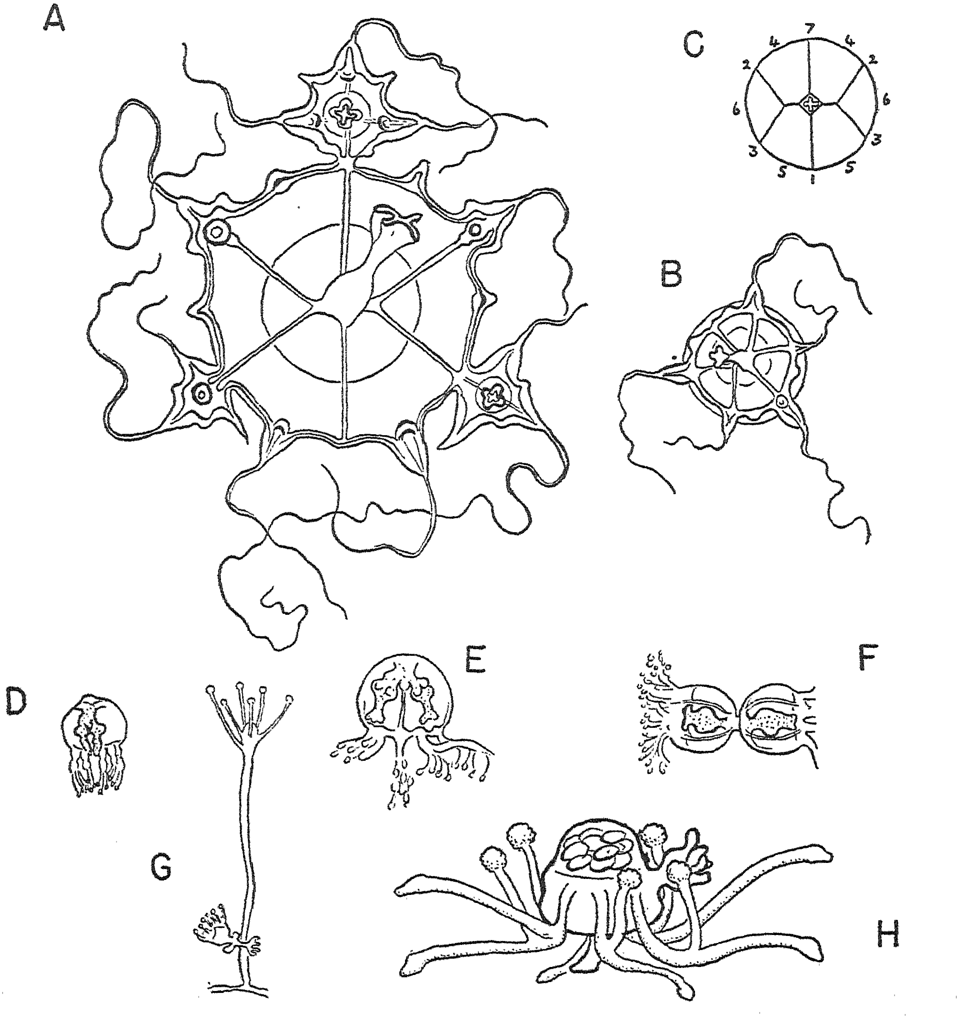

Fig. 9. Budding in the Anthomedusae

Niobia dendrotentaculata. A, medusa with tentacle bases transforming into medusae; B, newly-liberated medusa bud; C, diagram showing order of development and liberation. (After Mayer.)

Cladonema radiatum. D, E, F, three stages in process of division of manubrium and bell. (After Pasteels.)

Clavatella prolifera (= *Eleutheria dichotoma*). G, hydroid budding medusae; H, mature medusa in creeping position, with eggs in dorsal brood sac, and medusa bud forming from side of bell. (G, after Hincks; H, after Hartlaub.)

Proboscidactyla ornata var. *gemmifera,* on the other hand, produces medusa buds from four stolons situated near the junction of the four radial canals with the stomach (Fig. 8, J), and the medusae develop suspended within the subumbrella (Fig. 8, K). According to Mayer (1910), these forms are typical of medusae from South Carolina southward. In cooler waters to the north, the sexually mature form may possibly be produced without passing through a juvenile budding phase. In any case, the gonads develop at the site of the budding stolons. *Proboscidactyla ornata* var. *stolonifera* is similar but has eight budding stolons at the second and third forkings of the radial canals, instead of four (Bigelow, 1909).

One of the most fantastic forms of asexual reproduction among medusae is that of *Niobia dendrotentaculata,* as described by Mayer (1901, 1910).

There are twelve tentacles, of varying age, and bilaterally symmetrical in arrangement (Fig. 9, A). Each tentacle bulb develops progressively into a medusa, the original tentacle becoming the oldest or primary tentacle of the new medusa. Each tentacle bulb develops in order of its age, at first one and then in pairs until all twelve original tentacle bulbs have been liberated as free medusae of the type shown in Fig. 9, B. When this has been accomplished, the residual medusa no longer reproduces asexually but progresses directly to sexual maturity. The gonads mature and the large eggs develop from the interradial surfaces of the surface, from which they are finally set free.

The first stage in the transformation of a tentacle bulb into a medusa is the appearance of a hollow outgrowth upon the floor of the subumbrella close to the tentacle bulb. This outgrowth consists of both ectoderm and endoderm. It shortly develops two pointed outgrowths on the sides of the tentacle bulb and these become new tentacles. As they grow, a younger pair appears farther out, and these are followed by another (Fig. 9, A). Even before the young medusa breaks free of its parent, the base of its oldest tentacle has started to repeat the process. The sequence of the appearance of the marginal medusae is shown in Fig. 9, C.

Cladonemidae

Two remaining medusae among those that commonly reproduce asexually belong to the Cladonemidae. The medusa of *Cladonema radiatum* is known to divide completely into two (Pasteels, 1939). The division commences in the manubrium, passing from the mouth towards its base. When the manubrium is thus duplicated, the bell as a whole gradually elongates and constricts, until just before final separation, two medusae are attached together by the apex of their exumbrellar surface, like siamese twins (Fig. 9, D–F).

Eleutheria dichotoma Quatrefages is a peculiar medusa produced by the hydroid *Clavatella prolifera* Hincks (Fig. 9, G, H). According to Hartlaub (1907), the eggs develop in an ectodermal brood pouch connected with the bell cavity by six interradial openings. Medusa buds develop upon the exumbrellar side of the ring canal, usually occurring at the same time as sexual reproduction.

Leptomedusae

In many ways the Leptomedusae are the most specialized of the four groups, particularly in the case of the hydroid phase. There is a general tendency for the medusa stage to be either limited in its elaboration or even to be reduced or omitted from the life cycle. As in the Anthomedusae, there are no known cases where a medusa develops directly from the egg. Eggs invariably develop into planulae, and the endoderm of the planula is formed either by unipolar ingression or by a multiple ingression or infiltration of cells from the outer layer. Apparently neither invagination nor delamination occur. Many studies have been made of the development and growth of the hydroid phases of the Leptomedusae s. Calyptoblastea, and cannot readily be reviewed here. Brooks' (1886) account of *Eutima mira* McCrady does however illustrate several points of interest. Cleavage results in this case in the formation of a hollow blastula, after which cells apparently slide inwards at numerous places and eventually form an inner endodermal lining enclosing a gastric cavity (Fig. 10, A, B, C). Mayer's statement (1910, p. 298) that the endoderm forms by delamination from the inner ends of the blastula cells is a conclusion not to be found in Brooks' original account. In any case, the planula so formed develops a purely ectodermal invagination at its narrow end, a feature also found in the planula of the anthomedusan *Turritopsis nutricula* (cf. Brooks, 1886). This ectodermal invagination disappears after attachment of the planula; and finally attachment of the stolon produced by the planula is by means of the general adhesive property of freshly secreted chitin (Fig. 10, D, E). The invagination recalls rather forcibly the adhesive attachment disc of the young scyphistomae of *Haliclystus* and related forms. The other feature noted by Brooks is the fact that the planula of *Eutima* increases in size considerably, in fact, even while it is a still single-layered blastula, and he was convinced that it possesses some method of nourishing itself.

The calyptoblast hydroids that produce free medusae may be roughly divided into campanulinids and campanulariids, the former producing medusa buds singly from erect or creeping stolons (e.g., *Campanulina acuminata*, Fig. 10, F), the latter from the lateral wall of specialized blastostyles, as in *Obelia*. Only in one known case, however, are medusae described which bud new medusae directly from the old. This is *Eucheilota paradoxica* Mayer (Fig. 10, G, H). In the young medusae the gonadial regions are situated close to the manubrium, but with further growth they ex-

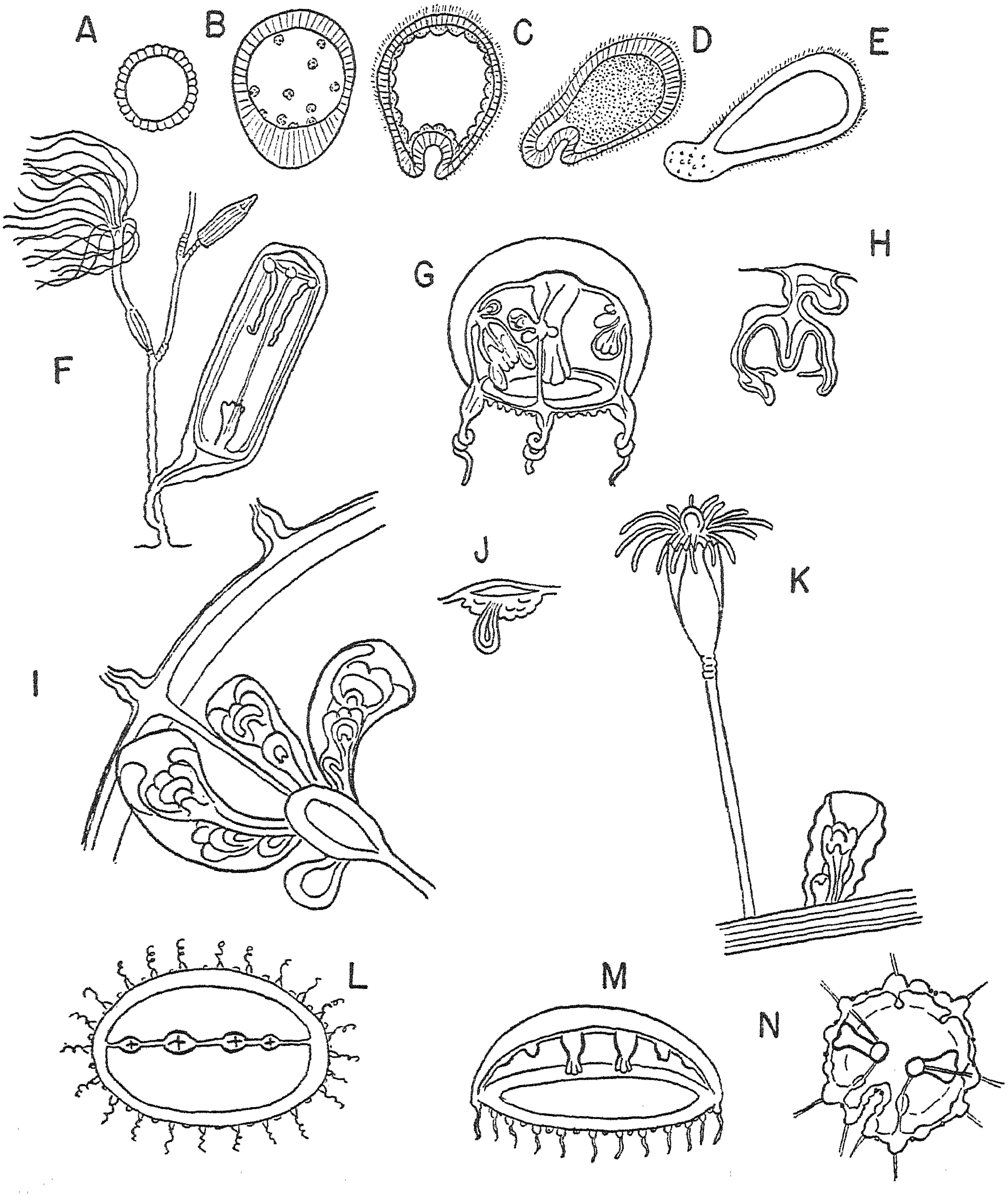

FIG. 10. DEVELOPMENT AND BUDDING IN THE LEPTOMEDUSAE

Eutima variabilis. A–E, development of the egg. A, blastula; B, infiltration of endoderm; C, D, young planulae with proximal ectodermal sucker; E, later planula with adhesive chitin replacing sucker region. (After Brooks.)

Campanulina acuminata. F, hydroid and medusa bud. (After Hincks.)

Eucheilota paradoxica. G, H, medusa buds forming from radial canal site, and section of a budding unit and gonad site. (After Mayer.)

Phialidium mccradyi. I, bell margin and radial canal, showing development of medusa buds from blastostyles in gonangia; J, side view of young gonad and a blastostyle; K, hydroid and upper region of a gonangium attached to alga. (I, K, after Brooks; J, after Mayer.)

Gastroblasta ovalis. L, M, ventral and side view, showing multiple manubria and elongation of medusa prior to transverse division. (After Mayer.)

tend along the radial canals. Medusa buds arise from the site of the gonads before gonadal histogenesis commences, and the medusae develop suspended within the cavity of the subumbrella. According to Mayer (1910, p. 255), both endoderm and ectoderm are involved in the outgrowths, and a succession of medusae arise from a single initial proliferation (Fig. 10, H).

Phialidium mccradyi (Brooks) (Fig. 10, I–K) is clearly a campanularian and the only one known in which the medusa buds medusae. It has been studied by Brooks (1887), Sigerfoos (1893), and Mayer (1910). Gonads may develop directly on the radial canals, or, more usually, outgrowths may form from the presumptive gonadal tissue. According to Sigerfoos, the single layer of small ectodermal cells thickens and become multilayered. The outer ectodermal layer becomes separated from the rest by a supporting lamella. The endodermal layer then evaginates into the thick middle layer of ectodermal origin, and at the same time loses its connection with the endodermal lining of the presumptive gonad. Thus cylindrical tubes of endoderm come to lie within the mass of ectoderm, and the blastostyles so formed can receive no food directly from the medusa stomach and the canal system. In effect they are tissue parasites. Typical blastostyles and gonangia are formed, complete with gonothecae, and the medusa buds are formed from the lateral wall of the blastostyle. Brooks also described the hydroid (Fig. 10, K), which appears to be a typical species of *Clytia*, and forms gonangia also characteristic of this genus. It is notable that medusae apparently can be produced by one method only, via the campanularian blastostyle, although the blastostyle itself may be produced either from a creeping hydroid stolon or from the gonadal site on the radial canals of the medusa.

The remaining leptomedusan to be considered here is the peculiar *Gastroblasta raffaeli* Lang (Fig. 10, L–N). Its hydroid phase is unknown. The medusa is characterized by having more than one stomach, a consequence apparently of growth occurring relatively more along one transverse axis than the other. This medusa reproduces itself by fission, a process described in considerable detail by Lang (1886). The bell margin grows inwards, the plane of division being at right angles to the long axis of the ellipse, and passes between the oldest and the next oldest manubrium. When about to divide, the oldest lithocyst divides into two and the marginal cleft passes between the products, until the medusa is cut completely into two halves (Fig. 10, N). Each part then develops new canals, manubria, and tentacles, until the original form is restored and the cycle renewed. A related form is illustrated by Mayer, *Gastroblasta ovalis* (Fig. 10, L, M), in which one canal passes the length of the ellipse and bears six or more manubria at one time. Reproduction by fission is probable, but is not certainly known.

GENERAL DISCUSSION

In general, the eggs of the Hydromedusae exhibit the same variability in size as those of the Scyphomedusae. Both groups contain species with large eggs that develop directly into medusae, both have forms with eggs of moderate size that develop into sessile hydroids, and in both cases there are some with minute eggs that grow and produce buds in rapid succession before any kind of functional organization becomes apparent.

Cleavage of the eggs in both groups is regular and without obvious pattern, but in *Haliclystus*, *Lucernaria*, and *Chrysaora* among the Scyphomedusae, and in *Eutima* and *Turritopsis* among the Hydromedusae, the blastula and early planula stages undergo very considerable growth, far beyond the potentiality of internal reserves. Wietrzykowski (1912), Teissier (1929), and Brooks (1886), respectively, insist on the existence of some means of external nourishment. There is little or no evidence that it is obtained by the blastomeres in a particulate form. It is possible, even probable, that the nutrient material necessary for this growth consists of the organic solutes usually present in some degree in seawater (Keys, Christensen, and Krogh, 1935), especially in coastal waters. The development in the Narcomedusae of medusae from minute eggs or buds within the gastric cavities of the parent or of some other medusa shows that the capacity to exploit such resources is undoubtedly present.

Excluding the vagaries of the life-cycles, there appear to be three principal ways in which a medusa may be formed. Medusae may develop in a rather simple and direct manner, as in the scyphomedusan *Pelagia* and occasionally in *Aurelia*, and in the trachymedusan *Liriope* and *Geryonia*. There are differences between the two groups, but the outstanding feature of the development is the growth and expansion of the embryo in the equatorial plane. An equally definite though very different procedure, namely, through the formation of an entocodon, occurs in the development of medusa buds in the Anthomedusae and Leptomedusae as a whole, and in *Gonionemus*, *Craspedacusta*, and *Limnocnida* among the Trachymedusae. In all of these the egg develops into a planula, and becomes a hydroid which produces medusa buds directly or indirectly. The development of a planula, in contrast to the direct development of a medusa from the egg, is associated with a marked polar organization and growth of the cleaving egg. The third method whereby medusae are produced involves the formation of an actinula. This stage consists of an elongated body with a ring of tentacles at the oral end. In most cases where it has been described or discussed, the reference has been to larvae free in the water, but the morphological stage is recognizable in some of the parasitic stolon larvae of certain Narcomedusae, and in the young scyphistoma of the Scyphomedusae.

The question arises what the actinula really does constitute, and the answer depends a great deal upon the context, for it can be interpreted in terms of procedures of development or in terms of phylogenetic relationships. Various opinions have been expressed concerning the evolutionary origins of medusae with the actinula and hydroid phases in mind. Bohm (1874) suggested that medusae evolved in the first place from floating forms of some kind. Claus (1882) also considered the medusae to be primary, and the hydroid a medusa larva. Mayer (1910) considered the anthomedusan, narcomedusan, and scyphomedusan types, at least, to have evolved independently. This view has some plausibility, but it has been carried to naive extremes by Fraser (1946) who regarded all sporosacs and abortive or sessile medusoid forms among the Anthomedusae and Leptomedusae to be medusae in process of independent, possibly arrested, evolution into free medusae. This is essentially a return to an older concept, the implications of which have apparently at no time been fully considered, namely, that the hydroid is the primitive form and that the medusa has originated as a gradual specialization of the reproductive members of a polymorphic hydroid stock. In recent times Uchida (1927) also has expressed this point of view.

Brooks (1886) adopted a compromise interpretation after an intensive study of the actinula larvae of the Narcomedusae. His hypothesis, strongly influenced by the theory of recapitulation dominant at the time, was that the actinula represents a primitive type of coelenterate from which the medusae have continued to evolve as free-swimming sexually mature organisms, and from which on the other hand the sessile hydroid organisms have arisen with subsequent elaboration of the processes of asexual reproduction. This viewpoint has its attractions, and it may be that the development of an actinula does represent the conservative, old-fashioned type of development of medusae. Even in such a case, however, it does not follow that the actinula was ever an adult form. A surer approach is to regard the actinula as the expression of a certain developmental situation.

Possibly the development of *Aurelia* gives the key to the problem. According to Haeckel (1880) the smaller eggs of *Aurelia* developed into planula larvae which attached and became scyphistomae, giving rise to young medusae by strobilation. The largest eggs developed, like those of similar size of *Pelagia*, into medusae directly. Eggs not quite so large became elongated larvae, as though becoming typical planulae, but continued to form tentacles and a mouth at one end while still in the free-swimming stage—in other words, became a typical actinulae. Subsequent development evolved the medusa organization by direct transformation, without involving a sessile phase. Accordingly, an actinula is formed as a stage in the development of a medusa egg when the size and polarity of the larva are of a certain rather critical value.

In all orders and classes of medusae there is a general tendency for the sessile hydroid stage, when such exists, to reproduce during its earlier phases of growth by means of asexually produced buds. In the Trachymedusae, Narcomedusae, and Scyphomedusae they are formed laterally from the body wall of the polyp and set free. In the Anthomedusae and Leptomedusae, the branching basal or erect growths are more or less comparable, at least in relation to the maintenance and augmentation of the medusa community. In any case the phenomenon is essentially one associated with the relatively rapid general growth of young stages in the life cycles, whether it is the 'frustules' of *Gonionemus*, *Craspedacusta*, or *Haliclystus*, or the budding of parasitic actinulae or the asexual "polyembryonal" budding of Narcomedusae, or the formation of lateral buds by scyphistomae of *Cyanea* (Berrill, 1949) or *Cassiopea* (Bigelow, 1900). The formation of outgrowths destined to become medusae rather than other structures is associated with growth in a transverse plane and a relatively slow polar or terminal growth rate, not only in the Trachymedusae but in hydroids in general (Berrill, 1949a).

Leaving aside the various ways in which medusae are produced by hydroids proper, the diversity of locations from which they are budded off from other medusae definitely indicates a multiple origin of this particular activity. Production of medusa buds from the surface of the tentacle bulbs, manubrium, radial canals, ring canal, and the aboral pole of the medusa, cannot be homologized more than as an exploitation of a general capacity for reconstitution and an ability of some sort to isolate regions from the innate wholeness of the individual.

When a comparison is made of the actual origin or initiation of buds produced by medusae, whether they develop into medusae directly or not, it is clear that both the unspecialized epidermis and endodermis are basically totipotent and capable of giving rise either to the whole organism or at least a large part of it. A comparison of the origin of gonads confirms this conclusion (Liu and Berrill, 1948).

In a general way, growth, budding, and sexual maturation appear to be closely related. In all orders the production of medusa buds takes place in small immature medusae. As the growth rate slows and adult size is approached, budding usually ceases and sexual differentiation ensues.

Lastly, relative growth in young medusae may result in simple or modified fission, as in *Gastroblasta*, *Cladonema*, *Niobia*, and *Polypodium*, but as implied earlier, this is a phenomenon an understanding of which would illuminate the nature of organism itself and is beyond the scope of the present discussion.

SUMMARY

1. The Hydromedusae is a heterogeneous group, the four orders of which may represent a considerable extent of parallel evolution.

2. Direct development of eggs into medusae without passing through sessile hydroid stage occurs only in the orders Trachymedusae and Narcomedusae. As in the class Scyphomedusae, there is a correlation between type of development and size and degree of polar organization of the egg.

3. Asexual reproduction, by a process of budding, may occur at almost any stage of the life cycle. It may be a form of polyembryony, a fragmentation of the cleaving egg or of a young bud. Buds or new medusae may form from an aboral stolon of a young medusa, or lateral outgrowths of a polyp. They may arise from the outer margin of a medusa or from the inner lining of the ring canal. They may also arise from tentacle bulbs, from the outer surface of radial canals, or from the outer wall of the manubrium. They may be formed by actual division or partition of the medusa as a whole.

4. The production of buds is associated with young and juvenile stages, and with the absence of gonads. Sexual maturity and even young gonads are in general associated with a cessation of budding.

5. Buds that develop into sexually mature medusae can arise from epidermis alone, endodermis alone, or from a combination of both kinds of tissues. Each type is accordingly totipotent.

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NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will occasionally appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to H. B. Glass, Associate Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

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GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

SCIENCE IS A SACRED COW.
By Anthony Standen. E. P. Dutton & Co., New York. $2.75. 221 pp. 1950.

> "The Long Island Rail Road afforded me plenty of time for writing this book. The more the train was delayed, the more time I had to write."—Acknowledgment by the Author.

Here is another in the long list of harangues against science. Generally they are written by metaphysicans who are given to worrying whether Science Can Save Us and If Not, Why Not? Occasionally one by a practicing scientist (usually with hygienic tendencies) will find an agreeable publisher. Of late, when some of the latter sound off they are full of self-condemnation and rather incoherently develop the theme, *Oh, my! What have I done?* But even such authors develop similar general ideas or, if they vary them, it is but slightly. The treatise under consideration is not very different. In fact, it might be said that other authors of similar essays have possessed greater gifts of literary utterance. This volume is principally concerned with the immorality of science and scientists, and citizens are warned to be very careful or they will have a bunch of scientific tyrants running amok and injecting the unwary with truth serum and then turning them over to "the most alarming scientist . . . the social scientist." This low fellow will then complete the nefarious business with that "typical instrument of the social scientist . . . the straw poll."

However, this book is unique in one respect: the town of Hauppauge, Long Island (the author's residence) and the Long Island Rail Road are brought in. A critical examination of the data does not warrant the conclusion that the L.I.R.R. is to be blamed for this volume, granted it is so terrible and unpredictable a railroad that even the Pennsylvania R.R. had to give it up. True, it is reported that only the strong of mind and stomach ought to hazard riding on it with any regularity. Nevertheless, the responsibility for this latest caveat against science and scientists must rest elsewhere. Scapegoats are to be avoided even when they take the form of such obvious public enemies as the L.I.R.R. There also appears little likelihood that the blame is due to the stark reality of life in Hauppauge, Long Island, for some truly first rate essays have come out of even such places as Baltimore.

> "One of the marvelous discoveries of Science is 'brain waves.' They are detected by an electrical device strapped over the head. They are very useful in diagnosing epilepsy, and they are intensively studied by scientists, trying to find out what happens inside the mind. Up to the present, scientists have not tried to regulate these brain waves, or to change them. If ever they do, we must keep a sharp eye on them. For since, as we saw before, science can tell us nothing about what is good or bad, and since scientists have

> not been trained to think any other way than scientifically, they have nothing but their own half-baked ideas to go on in deciding *whose* brain waves are to be changed, and what to change them to" (p. 203).

No one with any depth of perception will dispute the fact that there are and probably always will be quacks and other odd fish who, by their own representation, pass themselves off as scientists. Such fakers and scientific moralists can be seen in and about the ranks of science. They are easily recognizable even by the majority of college sophomores. Generally they are considered nuisances not to be taken seriously. When they occupy high places, as occurs all too frequently, they are more painful nuisances, but still only nuisances. That Standen has not been able to recognize them and is alarmed by them and their idiotic bombast simply means that he has been taken in by them. For apparently similar reasons he views with equal alarm those professional educationists or boss schoolmarms who, when seeking solutions for the eternal teaching enigma of trying to make Joe Doaks think, sometimes come up with proposals so pathological that even the public is provoked to merriment. But, for some very obscure reasons, Standen regards such pedagogues as also scientists and their silly extravagances as science. The net result is a confused author full of vague fears and still vaguer fevers.

> "The first purpose of Science is to learn about God and admire Him through His Handiwork. If any usefulness comes in—as it does in large quantities—why so much the better" (p. 200).

Although on occasion Mr. Standen exposes some of the nonsense uttered by so-called scientists, it appears that some of his own notions about science are not altogether different (even though they may be vaguely in a negative vein). Accordingly, science or any intellectual effort is duty bound to solve all important human problems. Any accumulation of data that does not teach us how to live or to distinguish between right and wrong or to lend itself to some moral or metaphysical interpretation is useless—unless of course it has some practical use. These ideas are not unfamiliar; they have been expounded over and over again by professional philosophers of a sort. There are, of course, many who will take issue with the suggestion that science is to compete with theology for customers, or that it is a branch of religion.

> "Evidently in biology there is the same tendency to utter pompous nonsense that characterizes scientists of all kinds. But does biology have the virtues of science? That is more questionable . . ." (p. 93).
>
> "Psychologists, following the biologists, who are themselves following the physicists, feel that at all costs they must be objective. Therefore they study man in a detached sort of way, as if they were not men themselves. Mr. Sidney Hook has seriously wondered (in Education for Modern Man) whether man is intelligent. He says this is an empirical question on which considerable evidence has accumulated. One would think that Mr. Hook, having made the acquaintance of some men, would know whether they are intelligent or not" (pp. 118–119).

It is distressing to see class distinction rear its ugly head throughout this book. May I earnestly suggest that all such obviously superior persons as chemists working at the Brooklyn Polytechnic Institute bend over backward to be tolerant of their colleagues in the other disciplines—even if such colleagues be clinicians or psychoanalysts.

Standen must surely be aware that there are those who consider the competence of certain individuals to pass on the intelligence of others an empirical question on which considerable negative evidence has accumulated. The book's dust jacket says, "What makes the book even more delightful and rewarding is the author's sense of humor. . . Standen's style brilliantly reconciles readability with precision of thought." Admittedly, there are a few humorous bits. However, the neighbor's child can come out with an occasional bright saying or two, which does not necessarily make it a Huneker or a Mencken.

Here is an elegant title indeed and much could have been written under it. Science may truly be a sacred cow, but what we have in this book is a superabundance of the male of that species.

David B. Tyler

PROBLEME DER NATURWISSENSCHAFTEN. *Erläutert am Begriff der Mineralart.*

By Paul Niggli. Verlag Birkhäuser, Basel. Fr. 18.50. xii + 240 pp.; ill. 1949.

In the summer of 1942 Professor Niggli gave lectures in Zürich on "the concept of species in mineralogy." They now appear, in expanded form, as Volume 5 of the series "Wissenschaft und Kulture." This book purports to show that classification, which plays an important role in biology, is also essential in the "exact sciences." The first 50 pages are philosophical; their presentation is difficult to follow. The remainder of the work constitutes a treatise on crystallography. One wonders for what readers this treatment is intended. The author states that it is not for his "Fachgenossen"; but, although mathematical symbolism is largely avoided, it is hard to see how a reader not versed in crystallography could appreciate it fully. The biologist courageous enough to tackle it may occasionally find interesting comparisons between the concept of mineral species and that of species in biological sciences.

The figures, mostly crystal-structure drawings, are excellent. The language, abstruse and ponderous, reaches dazzling heights of hyphenated pomposity. For example, it appears that there are two scientific methods: one is the "abstrakt-generalisierende, atektonisch-imperative, ursächlich-erklärende Methode"; the other is the "vergleichend-systematische, tektonisch-normative, urbildlich-erläuternde Methode"! The publisher did a good job of bookmaking.

J. D. H. & Gabrielle Donnay

* * *

UNESCO: its Purpose and its Philosophy.

By Julian Huxley. Public Affairs Press, Washington, D. C. $2.00 (cloth); $1.50 (paper). 62 pp. 1947.

The last 2 volumes of the *Bulletin of Zoölogical Nomenclature* each contain a page on which gratitude is expressed to the United Nations Educational, Scientific, and Cultural Organization for financing the publication. This was the first intimation I had received that this organization was making any progress at all in its efforts to promote "all aspects of education, science, and culture" throughout the world. There is ample evidence of the need of just such a work as this, written by the director-general of the United Nations Educational, Scientific, and Cultural Organization, for the purpose of expounding the philosophy of this arm of the United Nations. Unfortunately, the treatise is not likely to be read by those who are most in need of its message.

At the date of publication, Huxley was not only the Director-General of UNESCO but also the executive secretary of its Preparatory Commission. A warning on the back of the title page of the treatise states that neither the organization nor the commission is responsible for the views expressed by their executive. This apparent lack of confidence is regrettable; it would have been better if the commission had read and approved the treatise in advance, so as to give the document the weight of official sanction. That they failed to do so, however, is quite understandable; after all, to vest supervision of the educational, scientific, and cultural activities of the whole world in an international organization is somewhat revolutionary. It has not been tried before. If it can be done properly it will mean that the inhabitants of the more slowly developing areas of the world will participate equally with the enlightened populations in the fruits of the intellectual activities of their cultural leaders. If done badly, it may result in the supervision of our arts and science by a superstate.

No sane person would differ with Huxley's statement as to what he hopes can be accomplished by UNESCO to assist all people to make their contribution to civilization and human welfare by making available to all the best they can offer and by improving that which is not the best. But many will feel that he has been unduly optimistic in believing that these desirable ends can be achieved in the foreseeable future under the present set-up. After all, the United Nations organization was established under an evil sign of the intellectual zodiac; a world war had just been fought and the conquered nations were too weak to participate in setting up an international organization for any purpose. Consequently they are likely to continue to think of UNESCO as a device of the victors to impose their culture on the rest of the world. This is my personal opinion and the reader should not hold the author responsible for it. He has undertaken a difficult and thankless task, for which he deserves the gratitude of all right-thinking people, who should do all they can to support and encourage him.

BIOLOGY: HISTORY AND BIOGRAPHY

The Life of Science. *Essays in the History of Civilization.*

By George Sarton; foreword by Max H. Fisch. Henry Schuman, New York. $3.00. x + 197 pp. 1948.

This volume was published as the keynote in a new series, The Life of Science Library, which has already expanded to nearly a dozen volumes through the worthy enterprise of its publisher. The theme is a valuable one, that of the close relationship which exists between the development of science and the history of civilization—and no more fitting person could be found to introduce the series than George Sarton. His scholarship stands above reproach; his lifelong efforts to make apparent the value of studying the history of science are to no little extent responsible for the growing appreciation of it at the present time; but most of all, Sarton sets so high an example of the worth of good writing in enlarging the appeal of the history of science to thinking people. It is a dangerously high standard for those who follow him.

None of the essays included in this volume are new. They range in date from 1916 to 1934, and appeared in many journals, scholarly and popular. However, they have been carefully arranged and edited to provide unity and to avoid redundance. There are 3 essays grouped under the heading The Spread of Understanding. These broach the theme closest to the author's heart. As he phrases it: "In short, the purpose of the history of science, as I understand it, is to establish the genesis and the development of scientific facts and ideas, taking into account all intellectual exchanges and all influences brought into play by the very progress of civilization. It is indeed a history of human civilization, considered from its highest point of view. The center of interest is the evolution of science, but general history remains always in the background." This is humanism of the highest order, so seldom seen among scientists.

The next group of essays is called Secret History, because "the essential history of mankind is largely secret"—the thoughts in the solitude of study or laboratory that forever enrich the intellectual and spiritual life of man. As examples, Sarton sketches the thought-life of Leonardo da Vinci, Évariste Galois, Ernest Renan and Herbert Spencer.

In the essay East and West in the History of Science, Sarton throws into relief the internationalism of science, not at all restricted to the last two centuries. The debt of Western Science to the Arabs, and back of them to the Greeks, and in still remoter antiquity to the Egyptians and Mesopotamians needs to be better heeded by the self-assured scientists of the West today. But the fate of Greek science stands as a warning to us: "What happened to Greece is that the intellectual activities of its people were hopelessly out of proportion to their political wisdom and their morality." The sterner moral and ethical principles in the stream of Hebrew history had to be fused in Christendom with the scientific spirit of the Greeks before modern science could be born. Is the blend, never too complete, breaking down altogether in the 20th century?

In the two last essays, Sarton writes of Casting Bread Upon the Waters, a sacrifice well-known to him. How good to look back and see, from the vantage point of one's later years, that it was indeed well done!

BENTLEY GLASS

SCIENCE IN LIBERATED EUROPE.

By J. G. Crowther. The Pilot Press, London. 18s. 336 pp.; ill. 1949.

In 1946, J. G. Crowther visited a number of countries which had recently been freed from Nazi occupation. As we would expect, the scientists of these countries did not have too easy a time. Their laboratories had been raided and valuable equipment stolen; many of the younger scientists had been conscripted and sent to labor camps; scientists of all ages had been coerced, some had yielded and collaborated with the enemy, others had resisted and been confined in concentration camps, while still others had been able to continue their work under depressing and harassing circumstances. A considerable fraction had joined the underground resistance and had become intimately associated with patriots from other walks of life.

Science, of course, suffered, but as soon as the Nazis were driven out recovery began. Make-shift equipment was constructed, new personnel was assembled and, in spite of shortages of all kinds, scientific research was resumed. It is very important that we know the status of science in the liberated countries if we are to understand the problems facing our European colleagues and if we are to help them intelligently.

Crowther has described post-war science in four countries which, together, give an adequate sample of the whole. They are France, Denmark, Holland, and Czechoslovakia. In each country he visited the leading institutions and interviewed the leading scientists. He discusses such topics as the present organization and support of research; the type of education and the living conditions of students; problems now under investigation; equipment in use or urgently needed; and the morale of scientists and their personal experiences during the occupation. The author's narrative is very detailed and precise. It includes not only a description of the physical plants, but also records of conversations with the liberated scientists and accounts of what they had suffered. It gives the impression of having been written on the spot, or at least of being composed almost immediately afterwards from copious notes. The author is obviously a good and accurate reporter.

Over and above the virtues just enumerated, *Science in Liberated Europe* has an additional value which is seemingly accidental. It was certainly not intended by the author. In brief, it consists of an unconscious exposure of the naiveté which has permeated so much of the thinking of scientists when they leave their fields of special competence. The author, a journalist who writes on scientific subjects, really offers himself as a truly beautifully prepared specimen put on exhibition by a three-year time lag.

Throughout the work the author expresses judgments not only on scientific matters, but on political ones as well. He has very definite ideas concerning certain competing ideologies, the proper relation of scientists to society, and such subjects as the support and direction of scientific research by the state. He expresses himself very freely on these and other controversial matters. He tells us just what his own beliefs and conclusions are, both directly and by implication. Unfortunately, his impressions and judgments, gained in 1946, are printed in 1949, and reviewed and evaluated in 1950. Recent events have not been kind to many of those who committed themselves to simple philosophies or who became true believers in one or another panacea. We should remember, however, that the opinions expressed by Crowther were held by a great many good scientists during the period when Russia was "our gallant ally" and when communists and non-communists were comrades in the underground.

No series of short quotations would give a complete or even fair picture of Crowther's political philosophy. Those which follow are just examples which impressed the reviewer.

"Quite possibly, in the long run, the experience of the French scientists in the resistance will prove of more importance for the future of science than the experience of the British scientists in their great war-time technical scientific efforts.

"The symbolic expression of the situation is perfectly exemplified with regard to atomic energy—in England, Sir John Anderson became chairman of the Prime

Minister's committee on atomic energy: in France, Professor Joliot-Curie occupied the corresponding position." (p. 13).

The recent somewhat embarrassed French government's explanation of Prof. Joliot-Curie's public statements on his personal loyalties and atomic research is in nice contrast to the author's implied approval of Prof. Joliot-Curie's appointment. A little later, in April 1950, Prof. Joliot-Curie was removed from office because his loyalty to France seemed questionable. In a panegyric Crowther adds:

"He [Joliot-Curie] joined the French Communist Party. As a Communist, he belongs to the appropriate cell, where he joins in the discussions of political questions with working men and women, and others from entirely different sections of the population, whom a scientist does not usually meet. He finds these discussions most valuable, especially on the relations of science to other social affairs, for his political colleagues, many of them shrewd workmen, make comments and observations which are not likely to occur to scientists with their professional, middle-class background." (p. 54).

In describing science in Dutch Universities, the author states:

"Nevertheless, the professors tend to identify the universities with themselves and believe that they can speak not only for themselves but for all of their subordinates and their students. The ideal organization would include all of the persons of the staff of the university, from the professor to the laboratory mechanic." (p. 286).

"The appreciation of Soviet principles and ideology have strengthened their [Czechs'] intention to develop science and technology by rational planned action." (p. 292).

A very interesting account is given of the author's visit to the monastery at Brno where Mendel made his revolutionary discoveries; but in 1946, of course, only a few were aware of the Communist threat to Mendelism and Crowther was not among them. His description of the monastery at that particular time is thus objective and valuable, as it gives us a picture of the place just before genetics was outlawed. Perhaps sometime in the future the monastery will again be liberated, and we can hope that then an observer as competent as Mr. Crowther will report on its state.

All in all, *Science in Liberated Europe* is valuable both for the author's objective reporting and for his subjective judgments. Historians of science can use both as source material in evaluating our epoch.

CONWAY ZIRKLE

◆

THE STORY OF THE JOHNS HOPKINS. *Four Great Doctors and the Medical School They Created. By Bertram M. Bernheim. Whittlesey House, McGraw-Hill Book Co., New York and Toronto.* $3.50. xii + 235 pp. + 9 plates. 1948.

The Johns Hopkins Medical School is not like those of other universities. The title of this book itself indicates that it is a peculiar institution. No one ever speaks of The Harvard, The Cornell, The Temple, or The Stanford, but it is always The Johns Hopkins, or even The Hopkins. Other medical schools have generally originated as accretions to older institutions which were experiencing the growing pains of the transformation from college to university status. But The Hopkins never was a college. It was born full-fledged without any larval stage, from the mind of its founder whose name it bears as Pallas Athene from the forehead of Zeus.

Johns Hopkins himself seems to have been the only figure of importance in this narrative with whom the author did not have a personal acquaintance. The pictures he gives us of the "Big Four" are vibrant with life and activity, and full of color, but that of the founder reminds us of a daguerreotype with the musty odor of the library stacks. This is not surprising, for Johns Hopkins did not come of a literary family. Neither he nor any of his relatives left any memoirs from which a passable biography might have been compiled, and a half dozen pages serve to exhaust all the data about him which the author has been able to assemble. After the opening chapter his name does not appear again. The reason why this relatively unlettered man chose to establish an institution of higher learning is obvious. His was a frustrated life. Unable to attend school because his labor was needed on the farm, and unable to marry the girl of his choice because her father objected to him, he became an embittered introvert. He then devoted himself to the liquor industry, thereby amassing the fortune by means of which he perpetuated his name.

Even after his death he was frustrated, for his executors, who had neither vision nor faith in the future of either the university or the city of Baltimore, broke his will and placed both the university and the hospital in blighted areas isolated by the freight yards. Eventually the university acquired the Homewood campus, but the hospital has been doomed to remain where the executors placed it, surrounded by the squalor of an environment that continues to deteriorate, and with little opportunity for expansion because all available ground is occupied. This has not been altogether a bad thing. The department of a hospital that makes the greatest number of contacts with the outside public is the dispensary, and the patronage of the dispensary is recruited chiefly from the lower strata of society. The residents of elite communities can be visited by physicians in their homes, or can obtain hospitalization elsewhere, but there is no one to minister to the needs of the underprivileged of East Baltimore except The Hopkins, and this is the way Johns himself would have wished it. He would never have been a welcome guest at the homes of the socially elite, but the slum-dwellers and the wharf rats respected him and loved him.

The story which the author tells us is not that of an institution, but of the men who made it famous. Probably no similar school has ever had so many luminaries on its faculty. One need only recall such names as Welch, Osler, Halsted, Kelly, Mall, Howell, Abel, Cushing, Baetjer, Dandy, to mention a few chosen at random, to realize this. The problem confronting me is to decide upon which of these to comment. Shall I speak of "Popsy" Welch, or of "The Chief," as Osler was known? Or shall I speak of Kelly, who always "opened with prayer," or of Abel's discovery of adrenalin for which he has never been given credit? Shall I speak of Baetjer, the pioneer in x-ray work, who had to undergo more than 40 operations for burns on his hands? Or should I speak of the time when the author, feeling that he was not getting as much as he should from the course on human anatomy, bribed a janitor to procure for him a cadaver from the dissection room which he took to his home in Kentucky, packed in a suitcase for summer study, unmindful of the fact that he was committing a penitentiary offense? Or of the time when a physician who had exhausted every remedy in the Materia Medica for hiccoughs finally administered a glass of water with the statement that it was a newly discovered drug that cost 30 dollars a dose? (The hiccoughs stopped at once and there was no recurrence.)

One of the best known stories about The Hopkins concerns the statement falsely attributed to Osler that men over 60 should be chloroformed. Actually, what Osler said was the relatively mild remark that college professors should be retired at the age of 60. That part of the commencement address in which the chloroform figures so prominently was a bit added by a writer of fiction. It certainly seems strange that such a misunderstanding should have occurred in the case of a man from The Hopkins, an institution noted for its respect to age. It is true that most of the Hopkins celebrities were young men when they first became associated with that institution, but it is also true that most of them remained until well past the three score and ten years allotted by the psalmist. Isaiah Bowman was over 60 when called to the presidency of The Hopkins, and a few years earlier another sexagenarian had been similarly honored, though he declined the call.

With apologies to those who may not be interested, I recall my own experiences at The Hopkins. Circumstances beyond my control prevented me from entering a graduate school immediately upon leaving college. When the way opened 14 years later, I circularized a dozen of the leading institutions of higher learning of the country. The replies were disheartening. "We are sorry but we can do nothing for you. You are too old." One even went so far as to attempt to dissuade me by suggesting that stenography might be a more practical study. But the reply from The Hopkins restored my faith in the American university. "You are the kind of man we are looking for. Come at once and let us get better acquainted." The letter was signed by Raymond Pearl, the founder of this journal, and it explains why those who hold a Hopkins degree look back on their student days with gratitude and appreciation.

◆

ECOLOGY AND NATURAL HISTORY

Beyond the Caspian: *A Naturalist in Central Asia.*
By Douglas Carruthers. Oliver & Boyd, Edinburgh and London. 22s. 6d. xx + 290 pp. + 21 plates + 1 map; text ill. 1949.

This book is an account of wanderings during the first decade of this century in Central Asia, a region with indefinite boundaries herein taken as the land stretching from the Oxus River on the east to the Gobi Desert on the west, between those more or less parallel mountain ranges, the Tien Shan and Kun Lun. The author is a collector of birds and mammals, with a compelling desire to roam the deserts of the earth. The greater part of the text is concerned with the natural history of the birds and mammals he met, wild sheep and pheasants receiving especial attention. Eighteen photographs and 6 reproductions in color of paintings aid in describing the landscape and some of its inhabitants. Little mention is made of contemporaneous human inhabitants, although a brief history is given of their forebears, who under Tamerlane terrorized much of Eurasia. Appendices review the classifications of Old World members of the genus *Ovis* and of the true pheasants.

J. L. Brooks

◆

Antarctic Conquest. *The Story of the Ronne Expedition of 1946-1948.*
By Commander Finn Ronne, U.S.N.R. G. P. Putnam's Sons, New York. $5.00. 20 + 299 pp.; ill. 1949.

Finn Ronne has given an account of a remarkable modern expedition to Antarctica, where he and his group spent 15 months (1946–1948). Although the biologist will find little direct information about the fauna or flora, since except for some plankton collecting a biological program was not planned, the document is a remarkable report on the "human ecology" in a remote and isolated scientific expedition. Moreover, the description of the infinitely detailed preparations and carefully meshed operations in the field gives the laboratory trained reader a feeling of "good research design." Ronne and his group (including Mrs. Ronne and Mrs. Darlington, the pilot's wife) mapped 250,000 square miles of heretofore unknown country, and corrected over 200 000 square miles of mapping. Geological geophysical, and meteorological studies were carried out by the scientists on the expedition. A most commendatory note on the expedition is the plan regarding the workup and publication of the data. By the time Ronne's *Antarctic Conquest* was printed, 7 scientific papers on geophysics and geology had been published, 10 on other subjects, and 7 more were in process.

M. C. Shelesnyak

◆

Field Manual of Plant Ecology. *McGraw-Hill Publications in the Botanical Sciences.*
By Frank C. Gates. McGraw-Hill Book Co., New York, Toronto, and London. $3.00. xvi + 137 pp.; ill. 1949.

Plant Ecology. *Fourth Edition.*
By W. B. McDougall. Lea & Febiger, Philadelphia. $4.00. 234 pp.; ill. 1949.

The first edition of McDougall served an extremely useful purpose (reviewed *Q.R.B.*, 3: 141; 3rd ed., 16: 496). Compact and fairly well written, it afforded a general introduction to plant ecology for the large numbers of general students with whom ecology still plays the game of "hard to get."

While the current edition has been reset (not without errors), it does not show the degree of revision which its possibilities would merit. Since this situation has already been documented with some care in another review (Egler, F. E., *Ecology*, 31: 312. 1950), it need not be further labored.

Gates' manual of field methods is likewise compact and well rounded in its emphasis. It is, moreover, a product of the kind of continuous revision that comes from working for 32 summers with the challenging students who have enrolled for field classes in plant ecology at the University of Michigan Biological Station. In that period these classes have achieved a deservedly high reputation for thoroughness.

Since the publication of Clements' pioneer *Research Methods in Ecology* in 1905 there has been—so far as I know—no general handbook of methods available for students. Aside from excellent but brief suggestions in textbooks, original papers have been the only, and necessarily scattered, source of directions. This fact alone should make clear the utility of Gates' *Manual.*

Methods are to the scientist what tactics are to the soldier. Today, even in the physical sciences, it is understood that technique must be adapted to the problem in hand as well as to the nature of the material used. This is, a fortiori, certainly true of ecology, where regional aspects play so great a part. It would be praise enough to say that Gates has written an excellent manual for northern Michigan, which he has. But this manual is so soundly conceived and so well done that it will be readily adaptable by any competent teacher for much wider use.

Paul B. Sears

◆

Le Peuple des Termites. *"Que Sais-Je?" Le Point des Connaissances Actuelles. Number 213.*
By J. Feytaud. Presses Universitaires de France, Paris. 45 fr. (paper). 128 pp.; ill. 1946.

In popular form, this is a well-written comprehensive survey of termites. Several genera are considered individually in terms of general characteristics, caste systems, nest construction, modes of digestion, reproduction, and defense of the colony. In the chapter La Vie au Grand Jour the internal operations of the colony receive review as a working superorganism. There follow 3 chapters presenting "both sides of the case": the symbionts and predators, termite damage to man's belongings, and La Réaction de l'Homme, which might well have been entitled L'Homme contre le Termite. *Le Peuple des Termites* makes little attempt at straight technicality, though a sufficient amount of detail is given. Bits of philosophy are mixed with an excellent historical review of our knowledge of termites and a consideration of the varied terminology applied to them in different countries. The bibliography includes 17 references to more technical papers by Feytaud, as well as a good representation of articles by other workers. There is no index.

L. S. Staples

◆

Fluctuation of Animal Populations. *Australian and New Zealand Assocation for the Advancement of Science. Presidential Address: Section D-Zoology. Perth Meeting, August, 1947.*
By A. J. Nicholson. Australian and New Zealand Association for the Advancement of Science. Paper. 14 pp. 1947.

In a long and somewhat difficult paper published in 1933, A. J. Nicholson (*J. Animal Ecol.*, 2: 132–178) set forth a general theory of biotic interactions as these regulate the "balance" of animal populations. Nicholson's monograph was essentially deductive in method and not lacking in intuition. While it is quite justified to state that this contribution remains an ecological classic, it is equally fair to conclude that the opinions advanced therein are not shared in entirety by all population ecologists and that many of the formulations remain to this date abstractions yet to be verified by field and laboratory study.

The crux of Nicholson's theory is that, while the physical environment produces marked fluctuations in census numbers, it is interaction between organisms that alone initiates and perpetuates some semblance of numerical control over the longer time span of a population's life history. Nicholson seems to synonymize such interactions with "competition." Thus, he confers upon this term a statistical meaning under which any relationship leading to the decreased probability of individual survival (or reduced reproductivity) through increase in population density could be called "competitive." This is an extension of the definition beyond the limits commonly recognized by most ecologists.

The present brief paper was delivered as a presidential address before the Australian and New Zealand Association for the Advancement of Science. It has two distinct merits: it expresses descriptively Nicholson's main ideas in simple, non-technical language; and it makes an intelligent plea for further work.

The key points made by Nicholson in his lecture can be arrayed as follows:

(1) Competition between animals, especially for food, is the mechanism that regulates abundance and leads to a state of balance.

(2) Such balance may be relatively stable, or quite unstable.

(3) If only replacement (by reproduction) occurs after a population has reached "the level of bare subsistence," the balance remains at equilibrium. Also, intraspecies strife induced by high density tends to produce stability by differentially eliminating weaker individuals through death, emigration, or both, and by favoring the more robust. The territorial behavior of mammals and birds is advanced as an illustration of this last point.

(4) Populations inadequately checked by factors other than food tend to exterminate themselves by exceeding their food supply. This may actually happen in small, special areas. In larger areas, marked oscillations in density occur owing to the release of population pressure as the density falls—this release permitting, first, the food resource to recover, followed, second, by recovery of the population itself. Such an oscillation can occur in space or in time.

(5) When predation destroys only the ill-fit among the prey, the latter achieves a density that jeopardizes its food supply. Contrariwise, when enemies attack "normal" individuals there is a tendency to keep the prey population at reduced level; the enemies have difficulty in satisfying their food requirements, and, in consequence, their numbers are limited. Under such conditions the prey population does very slight damage to its food plants.

(6) Mass emigration occurs with some species when population pressure builds to a critical threshold. This prevents the depletion of the food supply to a level that would cause mass starvation, but it does lead to violent oscillations.

(7) Epidemic disease can also produce oscillations. The incidence of disease is correlated with high host density and with the resultant malnutrition of the host species.

(8) "Superimposed upon this complex system of balance are climatic fluctuations; while below it, and supporting the whole system, are the physical environment and evolution, which together have determined which plants and animals can live together and react with one another in any particular place."

Nicholson concluded his address with the following statement: "In our investigation of the population problem we must make full use of all means at our disposal, which can broadly be classified as field observation, experiment, and theory. Field observation should lead to experiment, and both these methods provide the materials for theory, which in turn suggests further experiment and checking by observation. These methods are inseparable, and we must use all three readily and with judgment to develop our knowledge effectively. At the moment, it appears to me, theory has outstripped observation, while experiment has been grossly neglected."

It is my present opinion that ecology will sustain creditable advances during the next several decades in certain rather broad areas of research. These include a study of microclimate, of community metabolism or "energetics," and of populations. The application of maturing ecological principles to man's welfare will also accelerate. In all such investigations the combination, as suggested by Nicholson, of field observation (plus field manipulation), laboratory experimentation, and theory will be both functional and necessary. By the nature of the case it is likely that such combination may be more readily achieved and perfected in the analysis of population phenomena.

THOMAS PARK

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A STUDY OF SMALL MAMMAL POPULATIONS IN NORTHERN MICHIGAN. *Misc. Pub. Mus. Zool. Univ. Mich., No. 73.*

By Richard H. Manville. University of Michigan Press, Ann Arbor. $1.25 (paper). 83 pp. + 4 plates; text ill. 1949.

A program of live-trapping and marking of small mammals (mostly rodents and insectivores) was conducted during the summers, 1940–1942, in the Huron Mountain region of the Upper Peninsula of Michigan. The work was done on 8 quadrates each 300 feet square (2.07 acres) and usually representing different types of forest habitat. Plant and animal associations of each type are described, and population data are presented on the species trapped. The woodland deermouse (*Peromyscus maniculatus gracilis*) was, on the whole, the most abundant mammal, though a spectacular increase of the short-tailed shrew (*Blarina brevicauda kirtlandi*) made the latter the dominant form in 1942. The relative abundance of the resident mammals changed constantly, but the brevity of the study did not permit critical treatment of these fluctuations. A tendency was noted for many species to become more numerous at the same time, particularly by the fall of

1941. The chief weaknesses in the discussion of fluctuations, in my opinion, lie in "balance sheet" assumptions, i.e., of more definiteness than exists in numerical values for home ranges, reproductive potentials, etc., that actually may be influenced a great deal by at least several important variables. The author's stated preference for the old concept of balance of nature seems to ignore the many resiliences occurring in population phenomena; but, on the other hand, his suspicions of oversimplifications in explanations of "cyclic" changes are entirely wholesome. Environment, considered in terms of "key factors," certainly may not be divorced from the life equations even of species known to fluctuate with a fair amount of periodicity.

Paul L. Errington

EVOLUTION

The Pterobranch Rhabdopleura in the English Eocene. *Bull. Brit. Mus. Nat. Hist., Geol. Vol. 1, No. 1.*

By Henry Dighton Thomas and Arthur George Davis; with an appendix on The London Clay at Lower Swanwick Hampshire by Arthur Wrigley. The British Museum (Natural History), London. 7s 6d. (paper). Pp. 1–24 + 3 plates; text ill. 1949.

A Re-consideration of the Galley Hill Skeleton. *Bull. Brit. Mus. Nat. Hist., Geol., Vol. 1, No. 2.*

By Kenneth Page Oakley and Montague Francis Ashley Montagu. 5s. (paper). Pp. 25–48 + 1 plate; text ill. 1949.

The new *Bulletin of the British Museum (Natural History)* is to be issued in 5 series corresponding to the Departments of the Museum. They will appear at irregular intervals, volumes (300–400 pages) not necessarily being completed within one calendar year.

The series in *Geology* begins with a paper describing the first fossil rhabdopleure, found in the English Eocene strata. Besides being of exceptional interest because of the lowly place of the pterobranchs in the phylum Chordata, this is also noteworthy because it helps to close the gap between the modern pterobranchs and the last dendroid graptolites of the Carboniferous.

The second paper publishes evidence that the famous Galley Hill (Swanscombe) skeleton is comparatively recent, in spite of its 8 ft. deep burial in the gravels of the 100-foot (mid-Pleistocene) terrace. The skull and mandible "show no features which cannot be matched in the contemporary population of Britain." Especially convincing are the results of fluoride tests, which revealed about 0.2 to 0.4% of fluorine, like Holocene bones, rather than 1.0% like Upper Pleistocene or 2.0% like mid-Pleistocene bones from the Swanscombe region.

Bentley Glass

Autour de la Crise du Transformisme. *Second Edition.*

By Pedro Descoqs. Beauchesne et Ses Fils, Paris. 33 fr. (paper). x + 102 pp. 1944.

The biblical account of the origin of man has always been a complicating factor in any discussion of evolution. Some Catholic theologians, such as Dorlodot and Messenger, have held that there is no contradiction between the story of creation in the Book of Genesis and the theory of evolution. Others, such as the present author, have continued to oppose evolution, particularly as it refers to the origin of man. Father Descoqs defines transformism as a mechanism of evolution consisting of a succession of minute changes in living organisms. He has assembled, from the writings of contemporary French scientists, a number of quotations to the effect that transformism is a hypothesis rather than an established fact. The author then proceeds to restate the traditional teachings of Catholic theologians concerning the origin of the world, the direct creation of man, and original sin.

Walter H. Belda

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Progrès ou Régression?

By Frédéric-Marie Bergounioux; preface by S. E. le Cardinal Saliège. Didier, Paris. 80 fr. (paper). 128 pp. 1947.

This book is a commentary on the theory of regressive evolution proposed in 1943 by Salet and Lafont. According to this hypothesis, the history of the earth consists of three major periods: first, the period of the creation and formation of the earth, up to the appearance of man; second, the Golden Age, during which nature achieved perfection when man appeared on earth; third, the period of regressive evolution, beginning with the fall of man. An important corollary of this hypothesis is that plants and animals which existed before man appeared on earth were immortal, and that after the fall of Adam and Eve, not only mankind, but also all other things, first became subject to death. The hypothesis of regressive evolution was published by Salet and Lafont with the Catholic imprimatur of Msgr. Gaudel of the University of Strasbourg, who commented that while this hypothesis is not contrary to Catholic theology, it is not the only hypothesis which explains established facts, and that whatever validity it has depends on the proofs alleged in its favor.

Professor Bergounioux is a geologist at the Institut Catholique of Toulouse. The first section of his book is a critique of the hypothesis of Salet and Lafont. The author points out that the succession of living forms established by paleontology is completely contrary to any hypothesis of regressive evolution. The second section is a summary of paleontological evidence dealing with evolution.

WALTER H. BELDA

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LA VIEILLISSEMENT DU MONDE VIVANT. *New [11th] Edition.*

By Henri Decugis; preface by Maurice Caullery. Librairie Plon and Masson et Cie., Paris. 120 fr. (paper). vi + 387 pp. + 10 plates; text ill. (1941); 1943.

The notion that evolution automatically results in "progress" has been dead a long time, and ought to be allowed to rest in peace. But here is another book—first published in France in 1941—to explain that evolutionary change is not often progressive. The first two chapters deal with species that have become extinct, have not changed for a long time, or have regressed. The larger part of the book is then devoted to considering the causes of extinction or evolutionary arrest. With a certitude that hardly seems warranted by the available evidence, the author ascribes the arrest and disappearance of species to parasitism, infections, metabolic disorders of endocrine origin, and derangements of reproductive habits. All species, he feels, are now afflicted by these disturbances to such an extent that evolution has come to its end.

Although Decugis displays a wide range of knowledge in his selection of examples, his understanding leaves something to be desired. The major flaw in the book is that the products of evolutionary processes are actually judged in the light of the human concept of progress, and thus condemned for reasons irrelevant to nature. Adaptation and survival are scarcely mentioned. Anthropocentrism moreover clouds the entire work; the termites, for example, "mènent une existence lente et lugubre dans la nuit noire des galeries des termitières."

Against this background it is not surprising to find that Decugis, who wrote off the white race in *Le Destin des Races Blanches*, now despairs of the entire human species. Still, in an era when mankind is truly in grave peril of its existence, it is surprising to find leprosy, Malta fever, and bubonic plague listed among the major threats to our survival. Not the least interesting thing about this book is that it went through 11 printings in a 2-year period while France was under Nazi occupation. There seems to be some satisfaction in pinning the plight of the human race on causes beyond our control.

FLORENCE MOOG

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GENETICS AND CYTOLOGY

AN INTRODUCTION TO MODERN GENETICS. *Second Impression.*

By C. H. Waddington. The Macmillan Co., New York. $3.25. 441 pp. + 5 plates; text ill. 1950.

It would have been better had the author revised this book, for modern genetics has advanced a great deal and a number of viewpoints have been altered in the past 11 years. Nevertheless, everyone who has tried in vain during recent years to secure a copy of this thought-provoking treatment of the subject will welcome its reappearance in print.

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STORIA NATURALE DEL SESSO. *Biblioteca di Cultura Scientifica. XVI.*

By Emanuele Padoa. Giulio Einaudi, Turin, Italy. L. 1200 (paper). 561 pp. + 2 plates; text ill. 1948.

This work is a notable example of a genre sadly lacking in our American scientific literature: a comprehensive uncondescending exposition of a fairly general subject, written seriously for serious readers who are not, however, specialists in the field. The clear, precise language of the preface gives a view of a scientific climate foreign yet not completely strange, to the American scene: the implied defense of the Morgan school of genetics, together with a defense of American scientific contribution, is a homily in itself to the reader on this side of the Atlantic. Written, as we are told, in the dark and distressing days of 1943–44 and completed just at the time of the news of Hiroshima, with all its foreboding implications for the future of science and society, the book is nevertheless a model of economical, serenely thought-out language, of wise choice of concrete examples for discussion, of clear illustrative material from the literature, uncluttered tables, and illuminating original diagrams. Padoa is a talented teacher who can summarize complicated matters in a deceptively simple style.

Characteristically, the first chapter at once justifies the title of the book by dealing with reproductive patterns throughout the biological world. Chapters on meiosis, gametogenesis, and fertilization follow. Later chapters are concerned with zygotic and phenotypic sex determination, sex differentiation, secondary sex characters, and sex reversal. Padoa has been particularly successful in presenting the classic foundations of each of these phases of his subject synthetically with more recent thought and investigation. That some modern work has been omitted is hardly surprising, in view of the isolation in which the manuscript was composed: what does surprise is that so much new work has been not only included but truly assimilated.

Of especial interest in the preface is the clear statement—one of the few explicit ones I have seen—the position tacitly taken by many biologists: that our science is fortunately a young and innocent one, to be dissociated morally from the terrors of nuclear physics. Each of these propositions seems highly questionable.

In particular, it seems that anyone who has willingly followed or employed scientific methods is somehow morally involved in the hard decisions taken by the nuclear physicists in these recent eventful years. However that may be, the detachment experienced by Padoa (and indeed by many of his colleagues in Italy) has been fruitful, and we wish him many and happier years in which to continue his investigations and his teaching, and in which perhaps even to become reconciled to the rigors of the atomic age and the witticisms of Samuel Butler. It is difficult to refrain from mentioning the unostentatious but very pleasing format of the book, or the author's handsome photographs of experimental fowls, with a delicate haze of Italian rooftops as a background.

Dorothea Rudnick

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Studies in Genius.

By Walter G. Bowerman. Philosophical Library, New York. $4.75. iv + 343 pp. 1947.

A quaint book indeed! The author has enjoyed his hobby of research in biography, and a mass of statistics and enumerations is the result. The 1000 eminent Americans chosen for review are considered from such points of view as the geography of their birthplaces, the season of the year at their births, and their blood relationship to others on the list. There seems to be significant evidence that the genius, as defined in this book, is born in a larger family than a person in normal families of the "upper" classes. However, exact information was available for only 274 of the eminent individuals and is probably biased in favor of the larger families. A similar situation was found for the children of the eminent persons. What information there was indicates a strong correlation between the type of genius and his body build. The cause of death was also correlated with the body form or somatotype. A similar study of world-wide genius comprises the second half of the book.

It is not expected that this book will be of particular value to biologists, though some of the sister sciences might find it useful.

Sheldon C. Reed

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Ergebnisse und Aufgaben der Zellmorphologie. *Wissenschaftliche Forschungsberichte, Naturwissenschaftliche Reihe, Band 56.*

By Dr. E. Küster. [Theodor Steinkopff, Dresden & Leipzig], J. W. Edwards, Ann Arbor, Michigan (Printed in Germany). $4.00. viii + 141 pp. [1942], 1947.

This book is one of a series edited by Liesegang of the Colloid Institute of the University of Frankfurt for the purpose of affording critical reviews of the literature of natural science during the past 10 years. Since the volume was first printed in Germany in 1942 and reprinted here in 1947, much of its timeliness is past. However, most students familiar with Küster's book *Die Pflanzenzelle* and his researches on protoplasm and plastids will doubtless want to read this one also. The text is based upon his lecture notes of cytomorphology, and although Küster is a botanist, the subject and treatment have validity and significance also for the zoologist. There are 8 chapters about protoplasm, the nucleus, plastids, ergastic substances, the vacuole, membranes, the cell as a whole, and protista. A list of representative literature citations follows each chapter. There are author and subject indexes.

Earl H. Newcomer

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Cytologie Végétale et Cytologie Générale. *Encyclopédie Biologique, Volume XXVI.*

By Pierre Dangeard. Paul Lechevalier, Paris. 1250 fr. (paper). iv + 611 pp.; ill. 1947.

No really satisfactory book on general or plant cytology has been available either for teaching or research reference. The author has attempted to fill this gap and has been, to a degree, successful. This work might well serve as a textbook for a course in plant cytology, but only as an added source reference for a general course.

The author states that he has tried to cover the various aspects of classical cytology as well as the more recent developments. In the latter respect the treatise could be much improved. For instance, the fields of cytochemistry and the newer aspects of mitotic abnormalities induced by various radiations, cell poisons, etc., are not exploited. The chapter on cytogenetics leaves much to be desired. However, these shortcomings are, at least in part, recognized by the author for he says "... que nous ne pouvons pas nous flatter d'avoir donné un aperçue de toute question d'intérêt majeur. ... Ce livre est donc plutôt une Introduction à la Cytologie qu'une Traité."

A. H. Sparrow

GENERAL AND SYSTEMATIC BOTANY

Phyton. *Annales Rei Botanicae. Volume 1, Number 1, November, 1948; Numbers 2–4, June, 1949.*

Edited by F. Weber and F. Widder. Ferdinand Berger, Horn N.-Ö. (Austria). (1) 30 Sch. (Domestic), S. fr. 10.00 or $3.00 (Foreign); (2–4) 90 Sch. (Domestic), S. fr. 30.00, or $9.00 (Foreign).

The appearance of a new botanical journal is always an event of considerable interest, particularly so when the new journal is edited and published in the Russian zone of Austria. According to the editors, both of the University of Graz, *Phyton* is intended to represent the whole field of botany rather than a specialized branch of it. Papers are limited to 16 printed pages but can be submitted in any one of the congressional languages. Actually, volume 1 contains 2 papers and parts of a third in English, all others being in German. One of these papers had previously been published in the United States, and a translation of it appeared in a German journal (*Physis* 2/3).

In all, 26 articles and 2 groups of reviews are included in this volume. The majority (14) of the articles may broadly be classed as representing the morphological sciences, 11 being taxononic, 1 paleobotanical, 1 each in the fields of phylogeny and evolution, respectively. Of the 10 remaining articles, 4 deal with vitamins and plants and 1 with anatomical effects of colchicine treatment. Other interesting topics covered are: the correct spelling of the name Ginkgo; the occurrence of mangroves in Upper Cretaceous deposits of the northern foothills of the Austrian Alps; the action of guard cells in aquatic plants; the permeability of protoplasm with regard to various substances; and the electro-physiological behavior of glands. The single plate included in this volume is a reproduction of one of the rarest botanical plates ever made. It is the work of the botanist Ignaz Friedrich Tausch (1793–1825) and represents plate 20 (last) of his folio *Hortus Canalius* . . . (1823–1825). The legend gives the name *Actaea nutans* Tausch. The author of the paper (F. Widder) identified this long lost species (and name) as a mutant of the North American species *Cimicifuga racemosa* (L.) Nutt., possibly referable to var. *serpentaria*.

Clearly certain fields are not represented in this volume, notably cytology, genetics, ecology, cryptogamic botany, and microbiology. Perhaps future volumes will remedy this deficiency. Although the workmanship and paper used in the production of this volume are remarkably good considering the difficult post-war conditions, most potential subscribers will be stunned by the differential subscription rates, ranging from 120 Schilling for Austrian subscribers to 40 Swiss francs and U. S. $12.00 for foreign subscribers. American subscribers are thus expected to pay about three times as much as the domestic rate. As no comparable American or other scientific journal sells for that much either at home or abroad, this policy is likely to curtail the circulation of this otherwise commendable journal from the very outset.

THEODOR JUST

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COLLEGE BOTANY.

By Harry J. Fuller and Oswald Tippo. Henry Holt & Co., New York. $5.75. 993 pp. + 1 plate; text ill. 1949.

When a teacher finds that students have read several chapters ahead of the assignment in a textbook he knows that that textbook has something not usually present in such works. Fuller and Tippo have made a comprehensive and informative textbook readable, in fact, enjoyable. *College Botany* is still a textbook, however, and not a book that skims lightly over some of the more amazing facts about plants. The reader gets a good introduction to an understanding of the structure and the operation of flowering plants. For anyone who wants to learn about such things as the relations of roots and soil, what botanists now know about the absorption of nutrients from the soil, how materials are moved within the plant, and what happens to them when they get to their destination, the early chapters give the story succinctly with diagrams and pictures that clearly illustrate the text. The discussion of the chemical processes can be understood by someone without much background, although the presentation is not toned down to the point where a student who knows chemistry could think that biochemistry is simple. The complex interrelations between plants and their environment is continually emphasized by reference to controlled experiments that have been carried out and by pointing out the agricultural and horticultural practices that are based on manipulations of either the plants or the environment. In fact, all through the book student interest is aroused and held by references to the usefulness of knowledge about plants and plant growth. A more complete discussion of the importance of plants to man is given at the end of the book. Often such chapters are not read by students because the preceding chapters of a book have so completely divorced plants from the world of everyday life that it is too late at the last to arouse interest in the reason why the knowledge of all kinds of plants is of consequence to man. But Fuller and Tippo lead up to their last chapter, making it a suitable conclusion to their treatment of modern plant science.

No review of *College Botany* would do it justice that did not praise the clarity and meaningfulness of the illustrations. Each one tells a story, and most of them tell stories that are not easily demonstrated by many teachers. All of them show what their legends say they show. Another feature that aids the student is the inclusion of summaries at the ends of chapters to make the main points stand out. All technical terms are printed in bold face type when introduced and are clearly described at that time. The glossary and a very complete index make the text workable and give the student a feeling that the authors had clear minds and knew what they were aiming at from the time they started organizing and writing the book until they finished the tedious labor of completing the index. When high standards are set and met by textbook writers, the users respond with a respect for and an awakened interest in the subject matter. Fuller and Tippo's *College Botany* stimulates such a response.

HARRIET B. CREIGHTON

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COLLEGE BOTANY. *A Basic Course in Plant Science By Clarence J. Hylander and Oran B. Stanley. The Macmillan Co., New York.* $5.00. xii + 638 pp. + 1 plate; text ill. 1949.

This textbook is intended for the traditional year course in general botany with Part I, The Plant Organism, dealing with the structure, functions, and problems of the individual seed-bearing plant, for the first semester, and Part II, The Plant World, for the second semester. This second part deals with plant groups, first from a taxonomic and morphological standpoint and then from that of plant interrelationships, and concludes with 6 chapters on plant ecology, heredity, and evolution. That the book can be used, however, for shorter "enriched" courses is pointed out by the authors. (Particular "blocks" and "gaps" could easily be chosen in line with certain trends in general education.) There are 453 figures, an appended list of common and scientific names of plants mentioned in the text, but few chapter summaries, no glossary, no suggestive list of topics or questions for study, and no bibliography or suggested reading lists for interested students. Many teachers may find these lacks a drawback, but perhaps the text is intended to include all necessary facts and to be sufficiently stimulating without wording of questions. The photographs, line drawings, and charts are uniformly excellent, and one welcomes the new illustrations. The headpieces at the beginning of each chapter are particularly attractive. Certainly it is a book with a wealth of information about plants, the organization is good, errors are few, and it is readable. Perhaps there is a better balance here between morphology, physiology, ecology, and the economic aspects of plants than in many textbooks. The emphasis is on a thorough study of seed plants, their practical and cultural values, and the importance of conservation or an intelligent use of our plant resources.

In the Preface, the authors have stated that their intention is to secure a more balanced content of subject matter, to appeal to the needs and interests of larger numbers and varieties of students, to develop an awareness of the importance of plants, and to utilize to better advantage visual instructional materials. In most respects the book has accomplished these aims admirably, but as with certain other recent voluminous books on botany one wonders if the increased number of pages involved in supposedly attracting and holding all sorts and conditions of students has not made it of such an encyclopedic nature that the average student finds more factual "meat" than he can chew or digest, and hence is provoked to greater coverage rather than being stimulated to thoughtful study involving a mastery of principles and a formulation of concepts.

CARROLLE E. ANDERSON

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A MANUAL OF THE PENICILLIA. *By Kenneth B. Raper and Charles Thom; with the technical assistance and illustrations by Dorothy I. Fennel. The Williams & Wilkins Co., Baltimore.* $12.00. x + 875 pp. + 10 plates; text ill. 1949.

There are probably few microorganisms and certainly few fungi which transcend the Penicillia in their importance to man. Within this single genus of fungi are found not only producers of powerful antibiotics of incalculable value in modern medicine, but "molds" of enormous commercial value. As illustrative of their diversity of activities and metabolic dexterity one might cite their importance as producers of organic acids, enzymes, their role in cheese-making, and in the deterioration and spoilage of foods, various manufactured products, etc. They also produce serious destructive fruit rots, and cause certain diseases of crop plants and even of man.

In spite of the enormous importance of *Penicillium* in our everyday life, the complex of species has remained for all but a few persons a baffling one. The literature of the group, in the two decades since the appearance of Thom's *The Penicillia*, has increased by leaps and bounds, and entirely new areas of investigation have been developed. The time was ripe, therefore, for a summation of our modern knowledge of *Penicillium*, and in Raper and Thom's book we have this need abundantly fulfilled.

After a short Preface there is a section entitled General Discussion, covering such topics as a historical discussion of the Penicillia, the generic diagnosis and synonymy of *Penicillium*, methods of observation, techniques employed, and features of structural and biological significance in describing species. This last section is unusually comprehensive, meticulously executed, and excellently illustrated. The fourth chapter of this section deals with the cultivation and modern methods of preservation of the Penicillia. The section concludes with a superb account of the history of penicillin and the methods employed in its commercial production.

Part II, the Manual Proper, opens with a chapter on the use of the manual. Here are described in careful detail such topics as the data necessary for identification (a sample data sheet being included), bases for classification, series, species, varieties, mutants, strains, etc. Since the 137 species recognized in this manual as valid cannot be effectively handled in a single key, species series are utilized in both the Diagrammatic and General Keys for Identification which are included. Once the series is known, a Series Key guides the investigator to the proper species. Under each Series is given a synopsis of outstanding characters, the Series

Key and a discussion of the Series as a whole. The species descriptions include citations, synonyms, comments, and numerous illustrations, both of colonies and of particular structures of importance in identification. Ten plates in full color greatly enhance the descriptions of the colonies. The final chapter of this section deals with *Gliocladium*, *Paecilomyces*, and *Scopulariopsis*, genera closely allied to *Penicillium*. These are treated in the same manner as *Penicillium*.

Part III is given over to reference material. It contains a comprehensive topical bibliography, with items ranging from acid formation, allergy and antibiotics, through deterioration, pathogenicity, and penicillin, to tannins. Other topics are also considered. This is followed by a general bibliography. After a species index and index to accepted species and varieties, a 24-page general index concludes the volume. Throughout are excellent illustrations by Dorothy I. Fennel. On the whole, the book is well made and printed, although a few instances of imperfectly printed and inky pages occur in the reviewer's copy. Typographical errors are remarkably few.

It seems almost needless to add that Raper and Thom's book is a star of the first magnitude which will unquestionably take its place in an American mycological firmament.

F. K. Sparrow

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Marin Flora. *Manual of the Flowering Plants and Ferns of Marin County, California.*

By John Thomas Howell; photographs by Charles T. Townsend. University of California Press, Berkeley and Los Angeles, California. $4.50. vii + 323 pp. + 25 plates; text ill. 1949.

Marin County, California, lies just north of the Golden Gate, and comprises 529 square miles of country that, in spite of its nearness to a great metropolitan center, has maintained a surprising amount of its natural vegetation. The topography is hilly or mountainous, and large towns have not developed. Within the county are such tourist attractions as Mt. Tamalpais and Muir Woods. The main part of Howell's book is devoted to a manual of the flora of the county. At the beginning is a key to the principal groups of families, and then keys to the families within the groups. Keys to genera and species are given within the treatments of the various families. Separate descriptions of species are omitted, but there are copious notes on habitat and local occurrence. Synonymy is limited to essentials, and common names are not belabored. There are 1313 species and 144 named varieties and forms included in the manual.

A rather long introduction describes the physiographic features of Marin County, its geology, soils, and climate, and its principal life zones and plant associations, along with a numerical analysis of the flora, and sections on geographic relationships. The introduction closes with an account of botanical exploration. The book is illustrated with 25 superbly executed half-tone plates illustrating the botanical landscapes of the region. A list of references, a glossary, and an index to common and scientific names are appended. Howell's manual has a place in the library of every student of western North American floras. It is scholarly, carefully documented, and finely printed.

H. M. Raup

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Observaciones sobre la Vegetación de la Provincia de Tucumán. *Monogr. Inst. Estud. Geog.*, 5.

By Jorge Hieronymus; revised and with notes by Hans Seckt. Instituto de Estudios Geográficos, Facultad de Filosofía y Letras, Universidad Nacional de Tucumán, Argentina. (Paper). 162 pp. + 1 map. 1945.

This is a reissue of an early but classical account of the vegetation of the small Argentine province of Tucumán. The original account, published in 1874 in the *Boletín de la Academia Nacional de Ciencias de Córdoba* (Argentina), is rare, a copy not even being owned by the library of the Córdoba institution where it was published. Since this work is still considered basic to the student of the vegetation of that part of Argentina, it has been republished. Seckt, of the National University of Córdoba, has clarified somewhat the heavy "Germanic" style used by Hieronymus in the original and has also appended important nomenclatorial changes where necessary. The phytogeographical account of Hieronymus is a descriptive one in the classical style, and follows in general the pioneer vegetational work of Grisebach (1872) so popular at the time. Hieronymus lumps his plant "formations" into 5 general types (chapter headings) which, though perhaps not now acceptable, may be correlated with the phytogeographical regions recognized in the province today. Besides its importance as a pioneer work, Hieronymus' account should be of much value to the Argentine ecologist who is seeking a clue to original types of vegetation in a province the native plant species of which have often been replaced by intensive agriculture.

W. H. Hodge

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Trees of the Countryside.

By Margaret McKenny; illustrated with lithographs by Alice Bird. Alfred A. Knopf, New York. $2.50. vi + 63 pp. + 32 plates; text ill. 1942.

This is a slender volume on some of our common trees, written from an appreciative rather than a scientific point of view. The accompanying lithographs by Alice Bird provide the necessary support for brief descriptions.

PLANT MORPHOLOGY

Plant Pathology.
By Sir Edwin J. Butler and S. G. Jones. The Macmillan Co., New York (printed in Great Britain). $10.00. xii + 979 pp.; ill. 1949.

The first third of this book is about general principles of plant pathology, and the last two-thirds describes representative specific diseases of plants. The section on principles is, in general, excellent. It is difficult to present logically in 330 pages all of the interrelated factors of host, parasite, and environment that lead to disease, but the authors have succeeded remarkably well. The nature of disease organisms and their life histories, the host-pathogen relationship and the nature of resistance, the influence of environment, pathological anatomy and histology, and disease control are covered with apparently few significant details omitted. Most of the examples given are of fungus disease, with a few references to those caused by bacteria. There are special chapters on virus and deficiency diseases, which seems desirable in view of their unique nature. There is also a brief classification of the fungi. Chapter 2 contains sections on the persistence of parasites from year to year, variation and specialization in fungi, and epidemics. It might have been more logical to put the discussion of variation and specialization with the chapter on resistance and susceptibility. The section on epidemics is largely historical and descriptive, and one feels a need for a summary section describing the way in which various factors contribute to the occurrence of epidemics.

Over 160 specific diseases are discussed in Part II, Selected Diseases. These are well chosen and for the most part adequately treated. The discussions are brief but complete, and detailed information is given when such detail is available and based on extensive research.

The book is well written and readable. Direct reference to authorities in the text is infrequent, which adds to its readability, but the reader may not like to turn to the references to know the names of contributors. The book was completed in 1943, and most of the literature cited dates before that; although there are some more recent references, more could have been used.

A student who has read and comprehended this book should have about as good an education in plant pathology as one can get by reading. It is probable, however, that a beginner may not appreciate some of the many excellencies of viewpoint and judgment shown here until he has had broader experience. The book, therefore, will bear repeated reading by students, and will do much to orient and clarify the information of more experienced plant pathologists. It will also be found highly useful to many people other than plant pathologists, whether they wish to get quick information about a specific disease or to acquire a sound background in general plant pathology.

Carl J. Eide

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Bits that Grow Big. *Where Plants Come From.*
By Irma E. Webber. William R. Scott, New York. $1.50. 64 pp.; ill. 1949.

A simple and effectively written and illustrated child's book on plant reproduction, covering seeds, tubers, spores, cuttings, etc. Easy-to-do experiments accompany the text to enable the youngster to see for him self or herself the manner by which plants grow and develop.

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PLANT PHYSIOLOGY

Praktikum der Zell und Gewebephysiologie der Pflanze. *Pflanzenphysiologische Praktika, Vol. II. Second Edition.*
By Siegfried Strugger. Springer-Verlag, Berlin, Göttingen, and Heidelberg. DM 27.60 (cloth); DM 24.00 (paper). viii + 225 pp.; ill. 1949.

In his new edition Strugger has produced an improved laboratory manual of cell and tissue physiology of plants. This book, already known to many American scientists, has been completely reorganized to include a number of subjects not treated in the first edition or in any other manual. It is the only book that covers adequately the subject of cell physiology as it has been developed in Strugger's laboratory. An English translation would be an important contribution to our botanical literature.

The subject matter, presented as individual experiments, is organized under 7 topics. First is the preparation of living cells and tissues, in which directions are given for the study of cells in both natural and artificial media. Second, microscopic studies of living plant cells and tissues are described. Included are analyses under light field, dark field, the fluorescence, and the phase contrast microscopes. The apparatus for each of these types of study is described. Next come cytomorphology and experimental cytology, making use of the techniques described in the first 2 chapters. Such phenomena as protoplasmic streaming, the outflow of protoplasm from cut cells, changes in viscosity, and plasmoptysis are covered. The nature of the cell nucleus under many experimental conditions is pictured. Chloroplasts and chromoplasts have been given detailed studies, using many reagents. Finally, the vacuole system of plant cells is described in many experimental phases. The chapter on plasmolytic methods has been brought up to date, but no important concepts have been changed. Quantitative methods for determining osmotic pressure by plasmolysis are presented in considerable detail. Chapter 5 describes experiments on absorption. The effects of various ions on plasmolysis forms are given. Vital staining, wound stimulation, and plasmolyzability are treated. Permeability studies of many types are described, and directions for laboratory experimentation are stated clearly. Using both light field and fluorescence microscopy, Strugger pictures the uptake of acid, neutral, and alkaline vital stains. The selective staining of many plant structures is described and illustrated. Not only are the methods given, but the theoretical significance of vital staining is treated in several places.

The book ends with 2 new short chapters, one on electrocytology and electrohistology as determined by treatment with dyes at various pH, the other on the transport of materials in plants. Translocation is broken up into cell-to-cell movement, transport through the xylem tissues, and movement in the phloem. Many of the experiments on translocation involve new dyes which serve as tracers. Though some of these are introduced into cut stems, others, such as K-fluorescein, are apparently absorbed through living cells and translocated through the phloem of relatively intact plants. This type of indicator is of the type long sought by physiologists to aid in translocation studies. While experiments to date have not clarified all of the problems in the translocation of food materials within the plant, they give more critical data than many of the older tracers. They should aid materially in the ultimate solution of many of these problems. This book may be highly recommended to all who are interested in the detailed study of the cellular physiology of plants.

A. S. CRAFTS & H. B. CURRIER

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LA PHYSIOLOGIE VÉGÉTALE. *"Que Sais-Je?" Le Point des Connaissances Actuelles.*

By Raoul Combes. Presses Universitaires de France, Paris. 76 fr. (paper). 128 pp.; ill. 1948.

Previous numbers in this series have dealt with everything from the *History of Africa* to *Radiation and Life*, and the series seems to be designed to provide the intelligent layman with an appreciation of the basic facts, methods, and generalizations of the most various subjects. In general, Combes has succeeded in highlighting the fundamental characteristics of the living plant and the problems posed by it, and has done so in a reasonably entertaining manner. The major topics considered are: (1) the incorporation of various substances into the living plant body; (2) metabolism; and (3) the energy relations of the plant. The historical account of the discovery of the basic facts about plant nutrition is well done, even if contributions of French investigators are slightly overemphasized. However, many important and interesting aspects of developmental plant physiology are completely disregarded, and other topics (such as respiration, plant hormones, and enzymes) do not receive sufficiently modern treatment. There are no references, the illustrations are few, and the emphasis of chapters is sometimes ill-placed. Despite these failings, the author has succeeded in cooking a reasonably palatable dish of "plant science for the citizen." Publishers of pocket-sized books in this country might well consider the production of a similar but somewhat improved volume in English.

ARTHUR W. GALSTON

◆

ELEMENTARY PLANT PHYSIOLOGY.
LABORATORY MANUAL.

By Stuart Dunn. Addison-Wesley Press, Cambridge, Mass. (1) $3.50; (2) $1.00. (1) v + 164 pp. 1949.

The 9 chapters of this brief book cover the plant cell, absorption, transpiration and translocation, mineral nutrition, photosynthesis, organic constituents, respiration, and growth. These chapters give the impression that not much new work has been done in plant physiology during the last 10 or 15 years. With few exceptions the literature cited dates before 1940. There are general reading lists at the end of each chapter, but no mention is made of several textbooks of plant physiology that are in use today.

The chapters on transpiration and translocation, mineral nutrition, photosynthesis, and growth are adequately done from a historical point of view. The chapters on organic constituents and respiration, the very heart of plant physiology, are sketchy, the work of Thimann, Goddard, J. Bonner, James, and others in these fields not being mentioned. The subject of enzymes is treated briefly, and it is interesting to learn that the author does not believe that any enzymes have yet been crystallized.

The author has prepared a laboratory manual to accompany the text. The experiments are standard in most elementary physiological laboratories and follow the subject matter of the book.

G. R. NOGGLE

◆

ECONOMIC BOTANY

LA SÉLECTION VÉGÉTALE. *"Que Sais-Je?" Le Point des Connaissances Actuelles, No. 219.*

By Germain Chalaud. Presses Universitaires de France, Paris. 75 fr. (paper). 128 pp.; ill. 1946.

This little book is a popular exposition of the principles and procedures of plant breeding (not of natural selection). It is divided into 5 chapters. The first outlines the scientific basis of selection or the laws of genetics. The second is concerned with "conservative" selection and defines the methods employed to perpetuate and propagate desirable varieties. The third considers "creative" selection through hybridization, which produces new characters by crosses between varieties. The fourth reviews the more complex situation in interspecific and intergeneric crosses. The fifth describes mutations and polyploidy. Chalaud writes clearly and convincingly. He uses scientific vocabulary unapologetically, as French popular science writers can with a considerable measure of impunity, because of the average man's relatively extensive vocabulary and feeling for words. For the same reason, it is found possible to do with very few pictures (only 9). The logical presentation of the subject, with reference to familiar examples, makes excellent reading for the layman, but the book will hardly be found to suit the requirements of the practical agriculturist.

The references cited are all French: some of them are rather inaccessible and two or three either obsolete or unreliable. Mention is made in the text of American, Canadian, and Russian work, but very little of it is described. On the other hand, many interesting histories of French plant breeding are given. These will be of considerable interest to the American student who is already versed in the subject and familiar with similar cases under quite different environmental conditions.

PIERRE DANSEREAU

◆

CHILD'S GARDEN OF FLOWERS.
CHILD'S GARDEN OF VEGETABLES.
By Robert V. Masters. Greenberg, New York. $1.00 each. 32 pp. each; ill. 1949.

Here is a clever idea, sure to appeal to the very young gardener—little books with simple directions, and with 5 packages of flower or vegetable seeds pasted right beside the appropriate descriptions. But be sure you get *this* year's edition, since old seeds, in spite of the 3-year guarantee, might bring disillusion. The pictures will help to tell the weeds from the flowers as they are growing up.

BENTLEY GLASS

◆

AMERICA'S CROP HERITAGE. *The History of Foreign Plant Introduction by the Federal Government.*
By Nelson Klose. The Iowa State College Press, Ames. $3.50. x + 156 pp.; ill. 1950.

America's Crop Heritage, in presenting the history of foreign plant introduction, is of interest to all botanists and agriculturists. In addition, it should be of value to students of economic history, as it fills a gap in the story of the economic development of the Nation. It also outlines the process of cultural transference and reveals America's debt to other countries.

Plant introduction has been necessary from the outset, since only a small proportion of our crop plants are native to the United States. The first 2 chapters deal with the Colonial Period and the early days of the Nation from 1770 to 1840. This was a time when government played little or no part in promoting agriculture, and the search for new plants was largely in the hands of individuals and agricultural societies. The third chapter is concerned with the first attempts by the Federal Government to aid in the introduction and growing of crops, and stresses particularly the work of the Wilkes, Perry, and other exploring expeditions.

In 1839, the Agricultural Division of the Patent Office was organized. Until 1862 it was the leader in the collection and distribution of seeds to the farmers of the country. Tea and sorghum were the principal new introductions during this period.

In 1862, a Department of Agriculture, headed by a Commissioner, was established. Several chapters are devoted to its varied activities. A great advance was made in agricultural education, and a beginning in the selection and breeding of new varieties of native wheats and the development of native grapes. Many important crop plants, such as the durum wheats, Egyptian cotton, jute, ramie, sugar beets, oranges, eucalyptus, and several forage grasses were introduced. In 1889, the first Secretary of Agriculture was appointed and given Cabinet rank. The great advances made under Secretaries Rusk, Morton, and James Wilson, and the even more spectacular progress made under their successors in the 20th Century, are outlined in the 3 final chapters. Of special interest is the account of the organization of the Bureau of Plant Industry, the work of the Office of Seed and Plant Introduction, and the activities of "special agents" or agricultural explorers, such men as Fairchild, Hansen, Carleton, Knapp, and Meyer. Among the many new introductions may be mentioned those of dates, figs, soybeans, and tung trees. Four official documents relating to the early days of plant introduction are given in an appendix.

ALBERT F. HILL

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GUIDE TO THE MEDICINAL AND POISONOUS PLANTS OF QUEENSLAND. *Coun. Sci. Indust. Res. Bull. No. 232.*
By L. J. Webb. Council for Scientific and Industrial Research, Melbourne. Free upon request (paper). 202 pp. 1948.

In the introduction of this bulletin the author has included a discussion of some historical aspects of botanical exploration carried on in Australia. In addition, he has told something of certain writings which deal with the chemistry and pharmacology of poisonous and medicinal plants, particularly those of Queensland. The need for much additional work on the chemistry and pharmacology of the plants is brought out. The various plant species have been arranged alphabetically by families, with the genera also in alphabetical order. With limited space, the amount of information concerning the medicinal and poisonous properties of any particular species is necessarily limited in most cases. Native, as well as non-indigenous plants of Queensland are included. The value of this publication is enhanced by the numerous sources of information cited. Many references are listed alphabetically by author. A well-prepared index to botanical and popular names is included on the last 18 pages of the bulletin. Workers interested in certain economic phases of botany, in plant chemistry, and in the pharmacology of plant constituents, should find this bulletin useful.

Maynard W. Quimby

◆

Vegetable Gums and Resins. *A New Series of Plant Science Books, Vol. 20.*

By F. N. Howes. Chronica Botanica Co., Waltham, Mass.; Stechert-Hafner, New York. $5.00. xxii + 188 pp.; ill. 1949.

The pages of this interesting and useful monograph are permeated with faint echoes of romance and adventure. To read of frankincense, myrrh, Chinese lacquers, and dammar is to be transported in time and space to a world far removed from the swift tempo and relentless pressure of modern life. The trade in gums and resins is as old as civilization itself, and the story is well worth the telling. Howes has assembled his material skillfully, so that a great deal of information about this ancient trade is compressed within a volume of modest dimensions.

The book is divided into two parts: the first deals with the gums, and the second treats the resins and their derivatives. A brief discussion of the physical and chemical properties of the subject matter introduces each division of the book. The interests of the author are strictly botanical, and this is made abundantly clear by the very limited attention given to chemical and physiological aspects of the subject. The importance of each of the many commercial gums is discussed, with reference to its place in historical and modern trade practices. The distribution of the gum-yielding species is outlined, and the botanical characteristics of these plants are described. A section is included on the methods employed in tapping the plants and collecting the gums. This is usually followed by a description of the quality factors which determine the various market grades and a list of the ways in which the gums are utilized in industry. A similar procedure is followed in the treatment of the resins. Helpful indexes to scientific and common names of plants and products referred to complete the volume. The monograph fills a useful place in botanical literature. A great deal of information has been gathered together from scattered sources and here made readily accessible to the reader in simple and direct prose. Numerous line drawings of the vegetative and reproductive structures of the important species of resin and gum-producing plants enhance the attractiveness of the book. Howes' book will be particularly helpful to economic botanists, but its appeal is by no means restricted to those interested in this phase of the science. The many interesting facts and observations contained within its pages make it a useful reference work for all who have a professional interest in plants and their products.

Donald B. Anderson

◆

The Native Forests of Cuyahoga County, Ohio. *The Holden Arboretum, Bull. No. 1. Sci. Pub. Cleveland Mus. Nat. Hist. Vol. IX.*

By Arthur B. Williams. Cleveland Museum of Natural History, Cleveland. $1.00 (paper). 90 pp.; ill. 1949.

This description of the probable composition and distribution of the native forests of Cuyahoga County, Ohio, is based on the observations and historical researches of a botanist who has been actively engaged in the study of the native flora of this county for the past 18 years. The small northern Ohio county is of special ecological interest because of its environmental variability. Within its boundaries two great continental physiographic provinces (The Appalachian Plateaus and the Central Lowlands) meet. This situation, coupled with a climate transitional between that of the east coast and the continental interior, has resulted in markedly diverse environmental backgrounds adaptable to a number of different plant communities. Characteristically eastern, western, northern, and southern plant associations are all represented in the area. Their present and probable presettlement status are discussed in some detail by the author. The bulletin is illustrated with a number of good halftones depicting views of current examples of the various forest communities, plus individual relict trees of the original forest which, during the past 150 years, have somehow escaped the woodsman's axe. A check list of native and introduced trees, with special remarks about their natural distribution and local occurrence, is presented at the end of the discussion. With reference to the exotics, one misstatement occurs: *Pinus nigra* is said to be "the dominant species in the 'Black Forest' of Germany" whereas, in fact, it is of little or no importance in that area.

Scott S. Pauley

◆

Better Douglas Fir Forests from Better Seed. *Agnes H. Henderson Research Publications.*

By Leo A. Isaac. University of Washington Press, *Seattle.* $1.00. xii + 65 pp.; ill.; two map enclosures. 1949.

Consideration is given in this publication to the comparative development in plantations of Douglas fir (*Pseudotsuga taxifolia*) grown from seeds from different geographic sources and representing strains or site races influenced by rainfall, temperature, elevation, latitude, and various environmental factors. The results of the study give rise to recommendations for forest planting, namely, that the seed source and the planting site should be well matched with respect to the several environmental factors affecting tree growth. The existence of site races and the adaptation of such strains to a rather narrow range of certain environmental conditions is proved by growing trees from seed from a number of different localities within the natural range of the species. Similar results were obtained both in this country and in Europe. Among suggested rules concerning seed procurement for reforestation with Douglas fir are limits as to the distance north or south of a planting site, limits of variation in elevation, similarity of mean temperature and frost-free periods, as well as indications of good health and suitable form of the seed trees. Superior natural strains of Douglas fir have been recognized which should be sought as seed sources within given areas. The superior strains will supply basic material for further genetic improvement through selection and hybridization. In the meantime, a system of seed certification is needed to promote development of the better strains for appropriate sites and thus assure greater success in reforestation. Evidently the standard of measurement for superior strains is rapidity of growth, coupled with desirable tree form and branching habits. A few localities reported to yield superior strains are mentioned.

BENSON H. PAUL

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TEXTBOOK OF WOOD TECHNOLOGY. *Structure, Identification, Defects, and Uses of the Commercial Woods of the United States. Amer. Forestry Ser., Vol. I.*

By H. P. Brown, A. J. Panshin and C. C. Forsaith. McGraw-Hill Book Co., New York, Toronto and London. $6.00. xxviii + 652 pp.; ill. 1949.

This volume is essentially a new edition of *Commercial Timbers of the United States* (1940), by Brown and Panshin. It is characterized by its broad scope, its keys, glossary, and the excellence of the photomicrographs. Significant changes in the new book are adoption of the International Code of Nomenclature, revision of the section dealing with the walls of xylary cells, addition of a third key to the identification of coniferous woods, and a more extensive citation of literature.

I. W. BAILEY

DISEASES OF POTATOES, SUGAR BEET AND LEGUMES.

By W. A. R. Dillon Weston; illustrated by Ann Murray. Longmans, Green and Co., London, New York, and Toronto. 4s. (paper). viii + 86 pp.; ill. 1948.

This is a companion volume to two similar, popular booklets by the same author, viz., *Diseases of Cereals* and *Diseases and Insect Pests of Vegetables.* The important diseases of potatoes, sugar beets, mangels, beans, peas, clover, and alfalfa occurring in Great Britain are described in a popular, readable, but authoritative style. Drawings by Ann Murray serve to illustrate the life history and symptoms of the diseases in a clear, interesting manner. Some 11 diseases of potatoes and 9 diseases of sugar beets are described, but only a few diseases of any of the legume crops are mentioned. The material presented should be useful to the cultivator in Great Britain. It is informative to the layman in any country, since many of the diseases described are common to agricultural areas of temperate climates. The features of most general interest are the sections devoted to the history of the potato and to a vivid account of the Irish potato famine of 1845–46. The late blight disease, which destroyed the potato crop of Ireland in those years, still serves as the most classical example of the effect of plant disease epidemics on human welfare.

J. H. MARTIN

GENERAL AND SYSTEMATIC ZOOLOGY

ATLANTIC REEF CORALS. *A Handbook of the Common Reef and Shallow Water Corals of Bermuda, Florida, The West Indies and Brazil.*

By F. G. Walton Smith; photographs by Frederick M. Bayer. University of Miami Press, Miami. $3.75. 112 pp. + 41 plates; text ill. 1948.

This attractive, readable handbook should prove extremely useful to all those interested in corals, whether amateur collectors or professional students of marine life. A most impressive feature is the magnificent set of over 40 full-page photographic plates taken by Frederick Bayer of the United States National Museum. They undoubtedly constitute the most superb collection of photographs of corals ever published and will appeal fully as much to all lovers of design as to collectors and biologists.

The text gives a clear and informative general account of corals and coral reefs in non-technical language. Included are competent although not extensive presentations of the various theories of coral reef and atoll formation, the structure, habits, and life history of corals, and methods of collection and preservation.

Each species is described both in technical and nontechnical terms and its distribution given as to Bermuda, Brazil, Florida, the West Indies, and the Bahamas. There are two keys, one based on the dead skeletons, and one, more technical, on both skeletal and other anatomical traits. There is a glossary and a bibliography. A future printing would be more useful with an index.

GAIRDNER B. MOMENT

SEA ANEMONES AND CORALS OF BEAUFORT, NORTH CAROLINA.

By Louise Randall Field. Duke University Press, Durham, North Carolina. $2.00 (paper). 39 pp.; ill. 1949.

Fourteen species of anthozoans (2 horny corals, 1 stony coral, 1 pennatulacean, 9 sea anemones, including 1 new species, and 1 ceriantharian) collected at Beaufort are described and figured.

A TEXTBOOK OF ENTOMOLOGY.

By Herbert H. Ross. John Wiley & Sons, New York; Chapman & Hall, London. $6.00. x + 532 pp.; ill. 1948.

The subject matter of entomology is rapidly growing away from the purely taxonomic approach which has been so common since the days of the classical textbooks of entomology. The title of this book is appropriate, but one should not expect to find the detailed systematics of the older books or of some more recent but less modern volumes having a similar title. This book does not emphasize any one approach to the subject, such as the physiological, economic, public health, systematic ecological or morphological, but rather is an excellent endeavor to give and integrate the necessary points of all of them for the insects. The first chapter covers the history of entomology up to the present day; it is followed by a comparative account of the general structures of the Arthropoda in the second chapter. The external and internal anatomy of the insects in a generalized fashion are considered next (2 chapters). With this foundation it has been possible to consider separately in the chapter on Physiology the functions of the organs and tissues previously described. A phase of entomology nearly omitted in entomological curricula as well as in standard zoological courses in the subject (yet here considered) is embryology; even so, a biologist will feel that the treatment is too scanty. Experimental methods are not touched upon. Orders of Insects, a taxonomic treatment, is the largest chapter in the book. The author's attempt to decrease the comparative-morphological and taxonomic aspects of the book has meant that only the larger taxonomic groups find a place; perhaps if this section were more detailed and set in smaller type, the student would not find it so often necessary to refer to other textbooks or reference manuals for the identification of insect groups. Coverage of insect paleontology occupies the ninth chapter; this field is a nearly neglected one in modern entomology and the author is to be commended for bringing the field into greater prominence. Ecological Approaches to Entomology (Chapter 10) is followed by the last chapter, Control Considerations, which leaves the impression that this is the purpose for which insects are studied. The book is the most rounded textbook on the subject published in recent years, but, like many college textbooks, it is written *about* a subject rather than *of* a subject. Experimental approaches to entomology, such as genetics, are not considered. Nevertheless, this book will be of indispensable value for college courses where a minimum of reference material is desired and a broad approach to the field of entomology is thought to be more important.

W. HOVANITZ

NEARCTIC HELINA ROBINEAU-DESVOIDY (DIPTERA, MUSCIDAE). *Bulletin Amer. Mus. Nat. Hist. Vol. 94: Art. 3.*

By Fred M. Snyder. American Museum of Natural History, New York. 65 cents (paper). Pp. 107–160. 1949.

A revision of the genus *Helina* of the Mydaeini, with a key and descriptions of 53 species, 11 of them new and 1 renamed.

COLÉOPTÈRES SCARABÉIDES *De l'Indochine. Première Partie. Faune de l'Empire Français, Volume III.*

By Renaud Paulian. Librairie Larose, Paris. 300 fr. (paper). iv + 228 pp. + 1 map; ill. 1945.

This part of the currently appearing *Fauna of the French Empire* deals with a portion of the scarabaeid beetles as they are known to occur in Indo-China. The author had for study the extensive collections of the French and British Museums. Keys for the identification of the families, subfamilies, genera, and species are given, and some 20 new species are described. The laparostict scarabs and the Dynastinae are covered in this volume; the Melolonthinae, Rutelinae, Cetoniinae, Lucanidae, and Passalidae are reserved for a second. The work is reasonably well illustrated, though the illustrations are of variable quality. The reviewer notes that Paulian has followed Schmidt's erroneous concept of the genus *Euparia*. It is probable that he has not seen the type species of this genus, which lives associated with certain ants in our extreme south.

EDWARD A. CHAPIN

POISSONS EXOTIQUES ET D'AQUARIUMS. *Atlas des Poissons—Fasc. IV. New Edition.*

By F. Angel. Éditions N. Boubée & Co., Paris. 500 fr. 163 pp. + 12 plates; text ill. 1949.

The hobby of keeping fishes in home aquaria grew greatly after the first World War. Since World War II it has become more popular than ever, not only in this country but also in Europe. The use of the small tropical fishes as laboratory animals in biological research has increased at the same time. The results of scientific experiments on aquarium fishes now appear regularly in foreign journals, as well as our own. Books describing the methods for maintaining fishes suitable for home or laboratory cultivation are keeping pace with the increased interest.

In France, Fernand Angel, an honorary assistant of the Muséum Nationale d'Histoire Naturelle, has contributed a volume to a series of popular books devoted to fishes in general (Atlas des Poissons). The fourth section of the book covers the fundamental principles of aquarium management. The introductory sections review topics concerned with the kinds of water suitable for the aquarium, the role of temperature in the different requirements of the many species of plants and animals, and some elementary physiology of respiration in fishes. The practical details of establishing a home aquarium are clearly stated, attention being given to shape and size of the aquarium, its location with reference to the source of illumination, bottom covering and the planting. Suggestions for proper management are outlined, especially those for feeding the fishes with dried and with living food. A useful, illustrated list of aquatic plants is given and their function explained. For those who keep fishes in outdoor ponds, some of the insect enemies of fishes are shown. The common diseases of aquarium fishes are described. The French adoption of the amateur's name of one of them would amuse the American aquarist; it is "Le Shimmy."

The main body of the book describes the various species of fishes which have been kept in aquaria. Many of them are not suitable for the American home aquarium, being much too large and far too rare. But these rare forms, chiefly from French colonies in Africa, are probably available to European aquarists. The description of the various species is concise, clear, and diagnostic. The black and white illustrations, if not scientifically accurate, will certainly help the reader to identify the specimens. In addition to the black and white figures, the book contains 12 color plates in which 60 species are painted in somewhat gaudy colors. Again, while these are not scientifically perfect, they do help to identify the species. Upon the whole, this book, slanted in the interests of the amateur, will be useful to French and European aquarists and to those in America who want to know what aquarium fishes are available in France.

MYRON GORDON

ORNITHOLOGIE ALS BIOLOGISCHE WISSENSCHAFT. 28 *Beiträge als Festschrift Zum 60. Geburtstag von Erwin Stresemann (November 22, 1949).*

Edited by Ernst Mayr and Ernst Schüz. Carl Winter, Heidelberg. DM 18. xiv + 291 pp. 1949.

Erwin Stresemann of Berlin is generally acknowledged to be the greatest ornithologist of our times. Biologists know him best for his great volume *Aves* in the Kükenthal-Krumbach *Handbuch der Zoologie,* which is by far the most authoritative and complete summary of information about birds. But a veritable flood of lesser works has come from Stresemann's pen, many of which have led ornithologists into new and rewarding paths or have served to link ornithology more closely with the other life sciences. Thus, his monograph on the birds of Celebes was largely responsible for the new ecological approach to the old science of zoogeography.

This collection of 28 original papers by Stresemann's students, friends, and admirers is a richly deserved tribute. Twenty-one of the papers are in German, 6 in English, and 1 in French. They run the gamut from life history, psychology, anatomy, embryology, and evolution to the history of ornithology. A. H. Miller, for example, discusses some of the ecological and morphological problems involved in the evolution of major adaptations and higher categories. Otto Koehler writes of his interesting discoveries in avian behavior. Emil Witschi outlines the utilization of egg albumen by the developing fetus. In a most interesting paper Gustav Kramer tells of a cage ingeniously devised to permit him to observe the escape movements of night migrants. He found that their efforts are usually oriented in one particular direction, though this may not coincide with the direction of normal migration.

These titles suggest the scope and originality of the contributions to this jubilee volume. Just as Stresemann's accomplishments span all of modern ornithology, so, too, this book gives a cross section of current interests in this science and its significance to other fields. For this reason alone many general biologists and all ornithologists will find it of great value.

DEAN AMADON

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THE QUAILS.

By Edward S. Spaulding; illustrated by Francis Lee Jaques. The Macmillan Co., New York. $6.50. xiv + 123 pp.; ill. 1949.

The Quails has as its purpose the presentation of accounts, convenient for the sportsman, of the quails occurring in this country. This has been done admirably. Each of the 7 species of quail that occurs within our borders is discussed in a separate chapter, which presents its description, range, life history, and comments about hunting it. A general introductory chapter precedes these accounts, and the book closes with chapters on transplanting and restocking quail ranges, and including random observations by the author. The illustrations are an outstanding accompaniment of the text, most of the quails discussed being represented by full-page color plates. In these the artist has caught the color and spirit of this intriguing and elusive group of birds.

A unique feature of the book is a chart that presents in a simplified manner the relationships of our quails to all those of the world. This is of particular interest because it proposes common names that might be useful to the sportsman for designating some of the generic groups of quails for which no common names have existed.

The author has a remarkable ability to describe personal hunting experiences and ideas in simple yet powerful language. Noteworthy is the recurrent expression of the theme that the greatest pleasure to be derived from hunting lies in mastery of this complex and difficult art, not in making large bags or in the killing of quail itself. In addition to the sportsmen for whom this book was primarily intended, it is recommended to those who are interested in problems of game management. This recommendation is made not only because of the obvious features of the book but especially because of the ease with which the author expresses the feelings that still lead men to support and pursue the art of hunting in a society as complex as ours.

John Cushing

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Tropical Birds. *From Plates by John Gould. Batsford Colour Books.*

With an Introduction and Notes on the Plates by Sacheverell Sitwell. B. T. Batsford, London, New York, Toronto, and Sydney. $2.00. iv + 12 pp. + 16 plates. 1948.

John Gould was the nearest equivalent to Audubon in Great Britain and his first volume of bird paintings was published in 1832, within a few years after Audubon's first plates. Otherwise Audubon, the artist and naturalist, had not much in common with the ornithologist and businessman Gould. Between 1832 and 1881 Gould completed 41 large folio volumes with no fewer than 2999 hand-colored plates. This incredible output was the result of collaboration between Gould, as author and publisher, and a group of artists including Mrs. Gould, Edward Lear, H. C. Richter, and William Hart.

De gustibus non est disputandum—there are many who prefer the natural simplicity of the Gould plates to the elaborate body postures of most of Audubon's birds. Being the work of several artists, the Gould plates are somewhat uneven in quality, but the best are among the loveliest of all bird portraits. Gould plates have now become collectors' items, and it will be appreciated by lovers of bird art that 16 of the most colorful bird plates, including 5 exquisite Australian parrots, are now available in excellent offset reprints. These are incomparably superior to the recently published reproductions of Audubon. The text comments by S. Sitwell are stilted and full of errors.

Ernst Mayr

◆

The American Trail Hound.

By Fred Streever. A. S. Barnes & Co., New York. $3.75. xviii + 202 pp.; ill. 1948.

American Sporting Dogs.

Edited by Eugene V. Connett; chapters by Gerald M. Livingston, Gladys F. Harriman, John Scofield, Robert McLean, Francis J. Squires, Arthur W. Lindsey, Chetwood Smith, Walter Roesler, Paul Bakewell, III, Prentice Talmage, David Wagstaff, Edward H. Carle, Lewis F. Gingery, Henry L. Ferguson, J. Gould Remick, Leon F. Whitney, Raymond Hoagland, William F. Brown, Edward J. Loring, Muriel W. Jarvis, Theodore A. Rehm, D. B. Ruskin, and Thomas W. Merritt; illustrated by Edwin Megargee. D. Van Nostrand Company, New York, Toronto, and London. $7.50. xiv + 549 pp. + 69 plates. 1948.

The Dachshund or Teckel. *A Complete Treatise on the History, Breeding, Training, Care and Management —With Chapters on Diseases and Their Treatment. Second Edition.*

By Herbert C. Sanborn. Orange Judd Publishing Company, New York. $4.50. xxii + 431 pp.; ill. 1949.

Such books as these are designed primarily for dog fanciers and the sporting fraternity. From a scientific point of view they may have two kinds of interest. There is usually an attempt to interpret basic scientific information to the lay public, and this may include facts relating chiefly to genetics and veterinary medicine but also to psychology and physiology. They may also include information which may be of use to scientists in indicating fundamental problems and possible experiments. For instance, geneticists may be interested in the effects of selection and inbreeding which have produced the wide variety of domestic dogs, and students of animal behavior may find indications as to the number of behavior traits associated with different breeds which are apparently inborn and how much they may be affected by training.

Streever's book, *The American Trail Hound*, makes no scientific pretensions but gives the results of his practical experience in an entertaining, anecdotal style. He also gives several pedigrees of American hound strains which might provide useful scientific information about how much inbreeding was practiced before the days of official registration.

American Sporting Dogs, edited by Connett, has 2 scientific chapters. In one, Leon F. Whitney gives a short summary on Mendelian heredity as it affects characteristics in the various sporting breeds. He also disposes of several of the common superstitions concerning animal breeding. This material is available in less condensed form in Whitney's book *How to Breed Dogs*. There is, perhaps, a tendency to overemphasize simple one-factor Mendelian heredity, particularly since many of the cases are based on limited experimental evidence, and the possibility of multiple factor inheritance is barely mentioned.

Lindsey gives a rather general discussion on the physiology of scent as it applies to hunting dogs but makes very little reference to scientific experiments on trailing. In his chapters on training and handling, Connett gives the impression that a good bird dog is made as well as born. The rest of the book is devoted to short chapters which include a brief history and the standard of physical form for each breed.

Those with special breed interests may consult more detailed works such as Sanborn's *The Dachshund*, a revised edition of a book originally published in 1937. In his scientific chapters Sanborn gives an introduction to Mendelian heredity and attempts to apply this, as far as information was available at the time of publication, to variability of form, coat, and color in the breed. This is a difficult task and again emphasizes how comparatively little genetic work has been done on the most familiar but in some ways least known of domestic animals, the dog. In his chapter on disease Sanborn gives a detailed description of symptoms of common dog diseases, together with advice based on his own experience. He is probably not as hopeful regarding the control of distemper as recent veterinary results would permit. For the rest, the book gives an excellent and scholarly history of the breed and its standards, as well as several pedigrees which indicate the type of breeding plan normally used. It would appear that dachshunds, as a general type of hunting dog, have a verifiable history as far back as the 16th Century, but that the first breed standard was not set up until 1879.

J. P. Scott

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Drawing at the Zoo.
By Raymond Sheppard.
How to Draw Farm Animals.
By C. F. Tunnicliffe. The Studio Publications, London & New York. 3s. or $1.00 each. 64 pp. each; ill. 1949; 1947.

These little books are so crammed with the superb drawings of two real masters of line and shadow in the representation of animal forms that very little space is left for the valuable hints they have to give. It scarcely matters—the biologist will prize the inexpensive books for their unforgettable pictures, mostly of mammals.

Bentley Glass

British Mosquitoes and Their Control. *Third Edition. Brit. Mus. Nat. Hist.—Econ. Series No. 4A. Printed by order of the Trustees of the British Museum by William Clowes and Sons, London and Beccles.* 6d. 27 pp. 1949.

Faunal Relationships of Recent North American Rodents. *Misc. Pub. Mus. Zool., Univ. Mich., No. 72. By Emmet T. Hooper. University of Michigan Press, Ann Arbor.* 35 cents (paper). ii + 28 pp. 1949.

ECONOMIC ZOOLOGY

Introduction to Applied Entomology. *Third Edition.*
By William J. Baerg. Burgess Publishing Co., Minneapolis. $3.50 (paper). x + 191 pp.; ill. 1948.

The third edition has many improvements over the previous editions (2nd ed., *Q.R.B.*, 18: 280). The illustrations are well prepared and clear in this lithographed type of printing. Like so many other publications covering this field it is written largely to meet the problems of the author's students. In general, the work treats the economic pests on the basis of their taxonomic arrangement. It begins with an account of the phylum Arthropoda and then discusses the various classes beginning with the Arachnida. The accounts are very brief and entirely restricted to those forms that are injurious or in some measure beneficial to man. Under the insects there is a brief chapter on their structure, their general biology, and as in all such textbooks a summary of the financial losses due to their activities. No indication is given here as to the vital importance of insects in present-day agriculture. A rather full account is given of the new and modern insecticides, and a brief account of biological control is appended. The accounts of the various pests discussed are well prepared and directions for their control are outlined. Various references are given under each order, and there is a general bibliography (very brief and incomplete) at the beginning of the work.

Robert Matheson

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Pests of Farm Crops. *Agricultural Series.*
By J. H. Stapley. Farmer & Stock-Breeder, London; E. & F. N. Spon, London. 21s. viii + 325 pp. + 19 plates; text ill. 1949.

This book on practical entomology, written by an advisory officer in eastern England, covers insects, nematodes, and other small animals that attack growing crops. The major part of the work is arranged by taxonomy of the pest, but the author has an extended listing by crops and by parts of the plant affected. He leans more heavily than most on the manipulation of environment as a control measure. This is a good practical treatise of direct use to the farmer.

James G. Horsfall

ANIMAL GROWTH AND DEVELOPMENT

MECHANISCHE GENWIRKUNGEN. *Funktionsentwicklung I.*

By Erich Blechschmidt. Musterschmidt KG. Wissenschaftlicher Verlag, Göttingen. DM 24.00. xii + 204 pp.; ill. 1948.

A reader expecting to find information on genic action in this book will be disappointed. Genes are mentioned only occasionally and perfunctorily, and have no bearing on the author's theory. The book actually deals with embryology and sets forth a theory of development which claims to solve a great many and ultimately all problems of morphogenesis. The theory is based exclusively on morphological observation of stained and fixed material from human embryos. The author intentionally uses only the morphological approach to embryology and appeals for his procedure to the method of Wilhelm His, to whose memory the book is dedicated. He expressly rejects the experimental and the comparative approaches and all conclusions derived from them. It is curious to note, therefore, that "experimental" thinking is actually used occasionally, e.g., when the author compares well and badly fixed preparations of lung primordia, in order to provide evidence for their actual state of hydration in vivo.

The book makes hard reading mainly because of the author's awkward style and a large number of typographical errors. Particularly disturbing is the author's tendency to use well-established technical terms, such as induction, determination, synapse, in a different meaning from those customary in biology.

The book's thesis, on the other hand, is fundamentally simple and plausible. The author points to the fact that embryonic epithelia have a different function from adult ones, since they always form membranes between an outer fluid on one side, such as the amniotic fluid or the liquid contents of internal organs, and the mesenchyma, with its more or less fluid ground substance, on the other side. The epithelium controls the exchange of "submicroscopic particles," particularly water molecules, between the two fluids. The epithelia (called "diathelia" in this connection) are therefore said to control a "diathelial metabolic field." It is assumed that different epithelia are different in the amount and direction of their secretory activity. The water used for secretion to the outside is assumed to be removed from the underlying mesenchyma, which becomes in consequence relatively dehydrated, and appears as a denser connective tissue. Furthermore, the arrangement of different epithelia and their differential activity gives rise to mechanical stresses, which are thought to be responsible for the arrangement of the mesenchyma in definite patterns that finally lead to organ formation. Morphogenesis is interpreted exclusively in terms of mechanical stresses arising through the activity of the epithelium. This principle is carried through for a large number of specific embryological processes, and anatomical facts like the arrangement of muscles in the limb and the particular arrangement of nerve fibers, both inside the central nervous system and in the periphery, are "explained" in this way. Chemical factors are assumed to be active only in the primary phase, i.e., the "diathelial" field.

While it is perfectly plausible to assume that the situations postulated in the theory do exist and that they may influence morphogenetic patterns, it appears unlikely that the wide generalization given to them by the author corresponds to the facts. Here, as elsewhere, no definite conclusions can be drawn from morphological description alone, and the experimental tests appear highly desirable.

This review would be incomplete without calling attention to the large number of excellent illustrations. The microphotographs are very distinct, and well reproduced. In addition, there is a large number of clear diagrams, drawn in pen and ink, which may be well worth the attention of students of anatomy and embryology.

ERNST CASPARI

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THE PRE-EGG STAGE IN BULLER'S MOLLYMAWK. *Biological Monographs, Number 2.*

By L. E. Richdale, 23 Skibo Street, Kew, Dunedin, S.W.1, New Zealand. Otago Daily Times & Witness Newspapers Co., Dunedin. 10s. from agents; 7s 6d. from author direct (paper). 50 pp. + 8 plates; text ill. 1949.

A 7-week sojourn on the Snares Islands (south of Stewart Island, New Zealand) was made by the author and a friend to study the pre-egg laying behavior of Buller's mollymawk (a species of albatross), *Diomedea bulleri.* A total of 346 nests was observed and 161 birds were banded. From these observations it was found that the males arrived at the islands on the average earlier than the females. The males awaited the arrival of the females, at which time coition occurred. Both sexes were frequently absent from the nest site until the day before the egg was laid, at which time the females returned, whereas the males did not return to the site until about a day after the egg laying. This is interpreted as indicating that two drives influence the behavior of the male: a coitional urge that impels him to await the arrival of the females; an urge to absence at the time of egg-laying preparatory to taking his first turn on the egg. Although a highly spectacular precoitional ceremony occurs, the writer does not believe that the cycles of both males and females must be attuned, as the males are apparently always ready to participate. Intruder males often successfully force coition on females not their permanent mates. Territorial defense plays a minor role, as trespassing is not common. The writer is also convinced that among these birds recognition of each other's sex is by sight rather than by any behavioral attitudes such as those usually attributed to nondimorphic species of birds. This valuable contribution, in addition to a list of cited references, is illustrated and has an index and some appendices. The latter describe in detail some of the more significant behavioral activities of the mollymawks.

Henri C. Seibert

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Dying, Apparent-Death and Resuscitation.
By S. Jellinek. A William Wood Book, The Williams and Wilkins Co., Baltimore. $3.50. viii + 263 pp. 1947.

It is strange that the literature of medical science, concerned as it is with the staying of death, has so little to say on the subject of death itself. This fascinating book is an attempt to remedy that deficiency. The work of a former professor of electrophysiology at the University of Vienna, the book is the fruit of more than 40 years of study, observation, and experiment on death and apparent death. The author firmly believes that dying and death are far more complex than is often supposed, that death is not easy to diagnose, and that thorough examination of newly "dead" bodies will not infrequently reveal signs of life that may be resuscitated. He feels that carelessness on the part of physicians in examining the dead has been responsible for many deaths that might have been prevented.

Since the book is intended primarily for medical students and practitioners, a large part of it is devoted to a detailed study of the death-process in age, disease, and shock. One of the most interesting chapters deals with the role of psychic factors in the last moments of life. In this section also the author pleads for more frequent autopsies, in order that more may be learned about the immediate and decisive changes that end life. The second half of the book deals with the techniques of resuscitation. The author vigorously condemns the popular life-saving methods as being lethal in themselves, and recommends instead methods which totally avoid compression of the chest. This portion of the book should be read by all who may be called upon to administer artificial respiration.

Well-written and easy to read, the volume is richly illustrated with examples from the author's own experience. Though the reasoning is occasionally uncritical, the pages are packed with important ideas and information. The book should not be missed by any student of medicine.

Florence Moog

ANIMAL MORPHOLOGY

Le Mimétisme Animal.
By Robert Hardouin, with preface by Etienne Oehmichen. Presses Universitaires de France, Paris. 280 fr. (paper). 221 pp.; ill. 1946.

Le Mimétisme: *Colorations Animales, Dissimulation des Formes et Déguisements, Ressemblances Mimétiques. Bibliothèque Scientifique.*
By Lucien Chopard. Payot, Paris. 930 fr. (paper). 335 pp.; ill. 1949.

The subject of mimicry, especially among the insects, is a fascinating one, possibly because there are no limits to the amount of imagination that is permissible. Anyone has the privilege of seeing resemblances wherever he may find them and of fashioning theories as to their importance in the economy of the so-called mimic. For centuries man has seen that certain animals resemble more or less closely certain other animals, or parts of plants, or parts of their own environments. But as yet no explanation has been made as to how this has come about, and no theory has been proposed as to why it has come about that is acceptable to all students of the subject.

Hardouin's book appears to be a rather uncritical exposition of the classical approach to the subject. The author passes over most of the damaging objections that have been raised against the theories of mimetic coloration and form. It does not appear to be an important contribution to the subject, either pro or con.

In the introduction to his treatise, Chopard first apologizes for the use of the term "mimicry." He writes that of course the word must not carry any idea of voluntary imitation but that it is more convenient to talk of "mimicry" than of "special procryptic resemblance."

The work is divided into two parts: in the first are the verifiable facts which have been recorded concerning homochromatism (concealing coloration) and homotypism (concealing form). The first of these often occurs alone, while the second is usually combined with the first. The second part of the work deals with the pertinent experiments which have been performed and the interpretation of the results of these experiments. It is here that complete agreement among workers cannot be reached.

In the Conclusion, Chopard brings out into the open the main objections that have been raised against the whole theory of mimicry. The most important of these objections is based on the fact that resemblance lies in the eye and brain of the observer. We have no assurance that an insect appears the same to a bird as it does to us. Since man is not the natural enemy of the insects and birds are, this is important. We do know from experimentation that certain birds do not see dark red, blue, or violet. There may be other and more important differences between human and avian vision that we know nothing about. Some cases of "mimicry" are carried to the *n*th degree. For argument, let us admit that an insect is benefited by resembling a leaf, provided the insect sits on the right twig of the right plant. Can there be any added advantage in the insect's resembling a leaf partially eaten by a caterpillar and also attacked by fungus?

There are times when Nature seems to play practical jokes.

EDWARD A. CHAPIN

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A Concise Laboratory Manual and Atlas for Comparative Anatomy.

By W. H. Atwood. The C. V. Mosby Co., St. Louis. $2.75 (paper). 114 pp. + 39 plates; text ill. 1949.

This manual prescribes and directs the routine laboratory work of an undergraduate course in comparative anatomy. It covers 5 forms: amphioxus, shark, necturus, bullfrog, and cat. The text, in which structures to be studied are underlined, is preceded by both systematic and type study tables of contents. The 38 full-page plates in the back are perforated to permit removal. It is a planographed, sewed, paper-bound octavo, well constructed throughout. The general appearance, particularly in the design and drawing of the plates, should encourage the student to neat, careful work. It should be very useful in its field.

F. N. LOW

◆

Practical Anatomy of the Dogfish, Necturus, and Cat.

By George C. Kent, Jr. Wm. C. Brown Co., Dubuque, Ia. $3.00 (paper). iii + 84 pp.; ill. 1948.

A careful series of directions for the study and dissection of the forms named in the title is given, along with a running commentary of relevant material. The 37 clear and fully labeled figures increase the value of the work.

JOHN A. CAMERON

◆

Laboratory Anatomy of the Cat. *Third Edition.*

By Ernest S. Booth; illustrated by Carl Petterson. Wm. C. Brown Co., Dubuque, Ia. $1.75 (paper). 57 pp.; ill. 1948.

This textbook of cat anatomy in special binding includes 61 excellent drawings all fully labeled and many full page charts, summarizing important information. The type is large and white space has been used effectively. The double-page folded diagram of the anterior spinal nerves is a notable feature.

JOHN A. CAMERON

◆

The Dissection of the Cat. *A Laboratory Manual.*

By Bruce M. Harrison. The C. V. Mosby Co., St Louis. $3.50. 109 pp.; ill. 1948.

This is an ambitious textbook and dissection guide with many fine illustrations on separate perforated pages. No labels are supplied, but label lines indicate the important loci to be considered and labeled by the student. There is a reference list of 55 titles and a 7-page section of Definitions of Terms.

JOHN A. CAMERON

◆

Atlas and Dissection Guide for the Study of the Anatomy of Domestic Animals. *Second Edition.*

By H. L. Foust and R. Getty. The Iowa State College Press, Ames. $2.50 (paper). 84 pp.; ill. 1947.

Beautiful plates of dissections of the horse, cow, pig, dog, chicken, and cat, with a key to each plate on the opposite page. Semi-schematic drawings of cross-sections at critical levels are included. Four chapters on the dissection of the dog follow the atlas, and each chapter has a useful list of references. The pages are not numbered, and there is neither index nor table of contents.

JOHN A. CAMERON

◆

Anatomy and Physiology for Students of Physiotherapy, Occupational Therapy and Gymnastics. *Second Edition.*

By C. F. V. Smout and R. J. S. McDowall. The Williams & Wilkins Co., Baltimore. $8.00. vii + 470 pp.; ill. 1948.

This textbook is designed for students of massage and medical gymnastics. It has been painstakingly prepared, and contains many original and excellent illustrations. It is well indexed, and contains the usual glossary. The chapters on Anatomy were prepared by the first author, who is Assistant Professor of Anatomy at the University of Birmingham, while McDowall of the Department of Physiology at the University of London prepared the part on Physiology. There are very few errors of fact of any consequence, and the method of presentation makes it highly suitable for those students for whom it was intended.

DAVID B. TYLER

◆

Anatomy and Construction of the Human Figure.

By Charles Earl Bradbury. McGraw-Hill Book Co., New York, Toronto, and London. $7.50. x + 198 pp.; ill. 1949.

This is a guidebook for painters and sculptors of the human figure. It provides sound, selected information on the form and function of bones and muscles in so far as they affect the proportions and detailed appearance of the outer body of the adult man and woman. Having been written and illustrated by an accomplished portrait painter and experienced teacher of art, special emphasis is placed on the principles of reproducing the essential features as structural entities at rest or in action. The young art student is supplied with much good advice on minor technical matters, especially on how to proceed in drawing what he observes with anatomical understanding of underlying structures. Of greatest aid are the many pencil or charcoal drawings and beautifully plastic, colored illustrations which generously supplement the text. Secondary sex differences are fully dealt with, in so far as they concern the artist, though at times in a rather dogmatic manner. Age differences, however, are unfortunately hardly mentioned.

Among the many books on human anatomy for artists, at least in the English language, this is an outstandingly useful, authoritative, and beautiful one. Anatomical terminology has been held to an unavoidable minimum and defined in an adequate glossary. The book and its profuse illustrations are excellently printed, except that the color of muscles and tendons in some of the plates resembles more that of decomposing than that of fresh tissue.

A. H. SCHULTZ

◆

HISTOPATHOLOGY OF THE TEETH AND THEIR SURROUNDING STRUCTURES. *Third Edition.*

By Rudolf Kronfeld. Revised and edited by Paul E. Boyle. Lea and Febiger, Philadelphia. $8.00. 514 pp.; ill. 1949.

The format of this textbook by the late Dr. Kronfeld has undergone little change in the present edition. The number and order of the chapters remain the same. There are more illustrations, which now consist mostly of good quality photographs of both gross and histologic specimens. There are a few graphs, tables, and line drawings. A bibliography, emphasizing works in English but including some foreign language publications, closes each chapter.

Kronfeld's original purpose, "to illustrate by means of human specimens the actual tissue changes that correspond to certain well-defined clinical conditions," is accomplished well and still describes the book adequately. The normal histology and physiology of dental tissues are not included. Most of the book deals with topics of interest primarily to dental and oral pathologists. But there are some sections of more general appeal, notable among them the chapter on dental caries, rewritten by N. B. Williams. This disease progresses by decalcification of the teeth in localized areas which are exposed to acids formed by bacteria of the genus *Lactobacillus.* Numerous factors are now recognized to affect its incidence. Its absence among natives whose diet is uncivilized contrasts markedly with its frequency in groups subsisting on food prepared by modern methods. Among natives otherwise free of the disease its incidence is correlated with the accessibility of civilized food. The concentration of fluoride in drinking water is now understood to be a significant factor. In areas where the communal water supply contains more than 1.4 parts per million of fluoride the incidence of dental caries is only about one quarter as great as in areas with less than 0.5 p.p.m. Experimental studies involving the addition of fluoride to drinking water are still in progress. The structural quality of the teeth, malhygiene, and certain constitutional states are also correlated with its incidence. The picture is that of a disease which cannot be certainly prevented in individual cases but the incidence of which, because of complex etiological factors, can be reduced by proper measures applied to the population at large. The edition under consideration has been brought up to date and is written in clear, readable style. It should continue to enjoy popularity in its field.

F. N. LOW

◆

NEUROLOGY. *Fourth Edition.*

By Roy R. Grinker and Paul C. Bucy. Charles C. Thomas, Springfield, Ill. $12.50. x + 1138 pp.; ill. 1949.

The fourth edition of Grinker's Neurology, with Paul Bucy as coauthor, and judging from the introductory note, as the active editor, is an excellent presentation of the field of neurology. Beginning with the technic of examinations, there is an excellent review of neuroanatomy and neuropathology, with every known syndrome or neurologic disease presented extensively and with quite adequate photographs or schematic drawings to illustrate the material. There is an extensive bibliography to complete the book. One finds little in the text concerning the psychosomatic and psychogenic aspects of some neurologic syndromes. This is all the more unusual considering Grinker's well-known interest in these facts. The book shows painstaking care in the presentation of the material and can be looked upon as one of the better textbooks and reference works on this subject.

WENDELL MUNCIE

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GREEN'S MANUAL OF PATHOLOGY. *Seventeenth Edition.*

Revised by H. W. C. Vines. The Williams & Wilkins Co., Baltimore. $8.00. viii + 1200 pp. + 12 plates; text ill. 1949.

The reasons for the popularity abroad of the 17th edition of this British textbook of pathology are apparent. It is written with extraordinary clarity, both as to descriptions of lesions and discussions of pathogenesis, and it contains many well-chosen illustrations. The material is complete for virtually every phase of pathology; even subjects sometimes neglected by other pathologists, such as the teeth, malformations, and parasitology, are included. Furthermore, many clinical correlations are given, with excellent summaries of normal physiological findings. For instance, normal renal function and tests are adequately explained before the clinical and pathological findings in renal failure are described. In spite of its readability, the book possesses two serious faults which prevent its being an ideal textbook for American students. Discussions of pathological conditions are oversimplified by the frequent absence of conflicting opinions. Even such fundamental subjects as chronic passive congestion of the liver, jaundice, and infarction are handled in this dogmatic manner. This would be thwarting to students who wish to draw their own conclusions from all the data available. Furthermore, there is no bibliography. Not a single reference is listed to enable the student to consult the literature for material of historical importance, or to investigate controversial subjects. The approach is that used by the majority of textbooks of pathology today, i.e., a division into general pathological changes, followed by chapters on the specific diseases of each system. The terminology is British rather than American, but there are no more differences in classification than one finds between 2 American textbooks. In summary, although this is evidently a popular textbook in England, it can add but little to our already voluminous American collection of pathology textbooks.

ELLA H. OPPENHEIMER

ANIMAL PHYSIOLOGY

LABORATORY MANUAL FOR VERTEBRATE PHYSIOLOGY.
By Donald M. Pace and Carl C. Riedesel. Drawings by Norma H. Pace. Burgess Publishing Co., Minneapolis. $3.25. viii + 227 pp. 1947.

This laboratory manual contains some 51 exercises in vertebrate physiology, including 15 nerve muscle experiments, 5 on the special senses, 17 on blood and circulation, 4 on respiration, 7 on nutrition, digestion, and absorption, and 1 on the endocrines (effect of insulin). Most of the experiments are designed for use of the frog or turtle, others for observations on man, and a few for the rabbit or dog.

DAVID B. TYLER

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SOME ASPECTS OF RED CELL PRODUCTION AND DESTRUCTION. *Ann. N. Y. Acad. Sci., Vol. 48, Art. 7.*
By Eric Ponder, William B. Castle, Harry A. Charipper, William Dameshek, Albert S. Gordon, S. Granick, and F. S. Robscheit-Robbins. The New York Academy of Sciences, New York. $2.00 (paper). Pp. 577–704 + 3 plates; text ill. 1947.

This paper-bound pamplet contains a series of 6 papers resulting from a Conference on Red Cell Production and Destruction held by the Section of Biology of The New York Academy of Sciences on April 19 and 20, 1946. The articles cover the cytochemistry and architecture of the red cell (Ponder), the influence of the endocrine system on hemopoiesis (Gordon and Charipper), the effects of experimental hemorrhage on hemoglobin and red cell production (Robscheit-Robbins), the relationship of iron and porphyrin metabolism to erythrocytes (Granick), the etiology of macrocytic anemias (Castle), and hemolytic mechanisms (Dameshek). In keeping with the quality of the publications of the New York Academy of Sciences, this book is carefully printed and well assembled. Dealing as it does with the minutiae of one of the most exhaustively investigated cells of the animal body, it is suited primarily to the specialist's library. The papers are well written by competent authorities, but their scope is so restricted that their reading is bound to be uphill work for the general biologist.

F. N. LOW

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THE RENAL ORIGIN OF HYPERTENSION. *A Monograph in American Lectures in Pathology. American Lecture Series, Publication Number 14.*
By Harry Goldblatt. Charles C. Thomas, Springfield, Ill. $2.75. viii + 126 pp.; ill. 1948.

Goldblatt, one of the better known students of this subject, has prepared an excellent little monograph in which 20 years of experimentation are summarized and discussed. The book is essentially designed for those whose interest is not sufficiently specialized or who do not have enough time to search out and read the original articles in this field. The monograph is readable and should prove of value to teachers of physiology in preparing lectures on a subject in which they may have little or no personal experience.

The following topics are included: methods of producing experimental renal hypertension; the effects of various experimental procedures, such as moderate and great constriction of one or both main arteries of the kidneys; the pathological changes that occur in various organs of animals showing persistent hypertension; the various mechanisms in the development of experimental renal hypertension; renin, hypertensinogen, hypertensin, and hypertensinase; the mechanism and site of formation and release of renin; the juxtaglomerular apparatus; the treatment of hypertension and a discussion of the similarities and differences between human, essential, and experimental renal hypertension. This is a short but excellent monograph that can be read easily in an evening by students of medicine.

DAVID B. TYLER

* * *

THE PHYSIOLOGY OF THE EYE.
By Hugh Davson, with a foreword by Sir Stewart

Duke-Elder. The Blakiston Co., Philadelphia. $7.50. xii + 451 pp.; ill. 1949.

There are in the field of vision excellent comprehensive handbooks by Duke-Elder and Helmholtz and many highly specialized monographs by Bartley, Granit, Polyak, Willmer, and others. It is difficult, however, to find well-balanced texts at an intermediate level. Davson's book is a welcome addition to the literature, since it is specifically designed as a general textbook for medical students, opticians, and physiologists. The contents of this volume are divided into 5 sections dealing respectively with intraocular dynamics and the transparent tissues (61 pp.); the mechanism of vision—photochemistry, flicker, acuity, adaptation, and the like (115 pp.); muscular mechanisms (75 pp.); visual perception—depth perception, dominance, rivalry, central pathways of the visual system (68 pp.); and optics (116 pp.). The weakest section seems to be the one which deals with visual perception.

Visual scientists will find much to complain about in this book because it is possible to compress the enormous literature on vision into a small text only by eliminating much interesting material and greatly condensing the rest. Considering the difficulty of writing a small book in this field, this is well done. It discusses a large number of topics in a competent way, and it should provide the student with a reasonably thorough and well-rounded introduction to the field.

A. Chapanis

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Biological Actions of Sex Hormones. *Second Edition. Entirely revised and reset.*

By Harold Burrows. Cambridge University Press, London and New York. $8.50. xiii + 615 pp. 1949.

This book is a new edition of a work originally published in 1945 (cf. *Q.R.B.*, 21: 299), which has since been widely known and used by students and workers in the field as a source book and general reference. The present edition follows closely the form of the original, although now greatly enlarged to cope with an enormous increase in the literature. The book is compactly organized into 6 major sections, as follows: the gonadotrophins; the gonad hormones—general aspects and relations; the androgens; the estrogens; the progestins; and the sex hormones of the adrenal cortex. The treatment of this immense area comprises not only the activities of the multiplicity of "sex hormones" in the physiology of the adult organism and in the development of the reproductive organs and functions; it deals also to a considerable extent with their complex interrelations with other endocrine glands and functions, in particular the pituitary and the adrenal. Each main section is further classified around numerous topics and subtopics. This breakdown has been carried out in considerable detail and contributes greatly to the usefulness of the book for general reference. The point of view throughout, however, is essentially that of the physiologist; the already very large literature on the experimental analysis of sex differentiation in all its various aspects is widely scattered among many sections and nowhere receives unity of treatment. As in in the first edition, considerable attention is given to the field of cancer research where hormones are involved.

In execution this plan has produced a well classified compendium of information. The principal data are assembled and set down concisely, and on the whole clearly, at least within limits imposed by the extreme brevity of treatment. There is welcome assistance to the reader in the form of numerous charts and tabulations. But there is too little attempt at evaluation of methods or data, and conclusions are reported for the most part in the form in which they are set forth in the original sources. In so comprehensive a field, it is of course impossible to report everything—some selection there must be; but there is sometimes room to question how much of what appears is attributable to selection and how much to the limits of one man's reading capacity.

This observation leads directly to the chief criticism which must be made. It is disappointing to find that the outstanding fault of the first edition—serious gaps in coverage—appears again in the present volume. Various important topics, the earlier history of which is developed, seem to have been passed over almost entirely so far as the literature since 1940 is concerned. Cases in point are the role of hormones in the control of sex differentiation, especially in mammalian embryos, and the very important effects of castration, both in the prenatal and postnatal periods of development. Again, in the section on the adrenal cortex the usual emphasis is placed on sex dimorphisms, in particular the sexual significance of the x-zone of the mouse's adrenal. The author, however, seems unaware of much recent work which has failed to produce any evidence of androgenic activity in this tissue. Publication at the very end of the war obviously accounted for many such omissions in the first edition, because of difficulties of access and communication, but these deficiencies should by now have been largely removed.

The new volume is durably and attractively bound and printed on a superior quality of paper. It has a well classified topical index and an enormous bibliography running to 35 closely printed pages. These features, together with the synoptic plan of organization, make the work convenient to use and extremely valuable as an introduction into a complicated field of investigation.

Robert K. Burns

ESSENTIALS OF GYNECOLOGIC ENDOCRINOLOGY *With Sections on the Male.*

By Gardner M. Riley. Caduceus Press, Ann Arbor. $3.00 (paper). x + 205 pp. + 1 plate; text ill. 1948.

This book offers an excellent synopsis of the basic facts of endocrinology, applied to the diagnosis and treatment of diseases of the female sex organs. In selecting these basic facts the author has drawn mostly on well-documented clinical material. He seeks to give a picture of human endocrinology rather than to describe the findings made on laboratory animals. It is a book for the physician rather than the biologist. One minor flaw in this excellent piece of work is the insufficient discussion of terminology in the chapter on the chemistry of the sex hormones. Alpha and beta structural configurations of the steroids are mentioned, but without further explanation these terms mean little if anything to the average medical reader. The illustrations are well chosen, and in spite of their excellent reproduction the price of the book is very reasonable. The book is recommended highly to students and practitioners of medicine. It should be on the shelf of every practicing gynecologist.

W. FLEISCHMANN

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CONTRIBUCIÓN DEL COEFICIENTE CITOLÓGICO *a la Fisiología y Patología de la Correlación Hipofisotiroidea.*

By Estanislao Del Conte. Librería y Editorial el Ateneo, Buenos Aires. $(Arg.)22.00. 87 pp. + 16 plates; text ill. 1949.

This is a very good monograph on the bioassay of the pituitary thyrotrophic hormone in the blood. The test object is the epithelium of the thyroid gland of the guinea pig. The test is very sensitive. The excess of thyrotrophic hormone in the blood of patients suffering from some forms of toxic goiter could be clearly demonstrated by this method. The histological technique is discussed in detail, with good illustrations. An excellent bibliography is included in this book, which can be recommended to specialists in the biological assay of hormones.

W. FLEISCHMANN

⁂

ELEMENTARY ANESTHESIA.

By W. N. Kemp. The Williams & Wilkins Co., Baltimore. $5.00. xii + 289 pp.; ill. 1948.

The author introduces the subject of elementary anesthesia with an excellent historical resumé. In the following chapters the pharmacodynamic and physiological considerations are discussed in a limited manner. The barbiturates, analeptic drugs, and curare are treated in so far as their place in anesthesia is concerned. The main portion of the text treats in a general manner the techniques of anesthesiology. Among these are included endotracheal anesthesia, anesthesia adapted to the patient's handicaps, anesthesia for thoracic surgery, and spinal anesthesia. Of special interest is the chapter on anesthesia for non-surgical conditions, which include such cases as acute barbiturate poisoning, sprained ankle, painful shoulder, and others.

The author has attempted to include in a comparatively small volume the entire field of practical anesthesiology. Of necessity it has been covered in a superficial manner. The diagrams and illustrations in the book are of special help in explaining the text. The style of the author is clear and concise, and this book should be very helpful to those who wish to review rapidly the field of general anesthesia.

JOHN C. KRANTZ, JR.

⁂

TEXTBOOK OF ANESTHETICS. *Seventh Edition.*

By R. J. Minnitt and John Gillies. The Williams & Wilkins Co., Baltimore. $8.00. viii + 568 pp.; ill. 1948.

The textbook of Minnitt and Gillies has now passed through 7 editions. This bespeaks the value of this compendium on anesthesia to the practicing anesthesiologist. In the seventh edition the general arrangement of the subject matter which appeared in the previous editions has been maintained. Newer subjects which have made their advent in the field of anesthesia, such as curare, and the new techniques in the administration of spinal anesthesia have been included. The authors have included a large number of cuts depicting new devices which have been developed for the anesthesiologist. The newer types of gas bags and anesthetic machines are shown. Of special interest is the chapter on the choice of an anesthetic. In this the authors consider patients with various diseases and suggest the best choice of an anesthetic under the particular conditions. On the whole, the book is well written and is recommended as a general and rather comprehensive treatise on the practical aspects of anesthesiology, containing sufficient pharmacologic background to warrant the consideration of the modern anesthesiologist.

JOHN C. KRANTZ, JR.

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INDUSTRIAL TOXICOLOGY. *Second Edition Revised and Enlarged.*

By Alice Hamilton and Harriet L. Hardy. Paul B. Hoeber, Medical Book Department of Harper & Brothers, New York. $7.50. x + 574 pp. 1949.

Mention is made in the preface of this second edition of the enormous expansion in the number of solvents, metals, and radio-active substances encountered in industry since the first edition appeared in 1934. For example, an entire chapter in the present volume is devoted to beryllium poisoning. Rapid developments in synthetic organic chemistry are constantly modifying industrial processes and consequently changing the toxicology picture.

There are 28 chapters in the book. Most of the common industrial metals are considered from the toxicological standpoint. One chapter is devoted to the asphyxiants, carbon monoxide, carbon dioxide, the cyanides, and hydrogen sulfide. The aromatic organic chemicals, including the volatile solvents, are discussed in 4 chapters. The remaining 10 chapters deal with the aliphatic series; chlorinated and brominated hydrocarbons; carbon disulfide; turpentine and tobacco; synthetic rubber; oil folliculitis; occupational cancer of the skin, lung, and bladder (3 chapters); radiant energy and stilbestrol. The material in each chapter could be made more useful to the reader by arranging the data under headings or captions, e.g., local effects, effects on the central nervous system, effects on liver and kidney, etc. Following such a schema the information would be more quickly available and more easily correlated. In addition, the authors might have evaluated the data from the literature more completely and have expressed opinions.

Only a page and a half are devoted to the rather important toxic insecticide, DDT, and the index reference to it is incorrect. The bibliography contains 1300 references. The volume appears adequate and will probably be useful to industrial hygienists, toxicologists, and those concerned with health hazards in industry.

C. Jelleff Carr

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Industrial Toxicology.

By Lawrence T. Fairhall. The Williams & Wilkins Co., Baltimore. $6.00. xii + 483 pp. 1949.

The author is Scientist Director of the Chief of the Industrial Hygiene Laboratory, U. S. Public Health Service. Rather than present the toxic effects of a substance as a series of case reports, he has attempted an appraisal and interpretation of the literature on each compound. As suggested in the Preface, this approach serves to give the industrial hygienist an evaluation of toxicity without having to digest a great volume of literature or to seek out many obscure publications. A short list of recent and more pertinent subject references is given at the end of each discussion.

As the physiologic response to a compound depends in large measure upon its physical and chemical characteristics, such as volatility, solubility, etc., these data have been included for each substance. Thus the occupational hazard may be more effectively evaluated by the reader. A novel feature of the text is the attempt to gather from governmental and other sources the extent of the production and use of a given material. The substances are arranged alphabetically in each part. Part I includes 71 inorganic substances. Part II includes 134 organic compounds. The introduction includes a brief yet comprehensive discussion of the relationship between chemical constitution and physiologic response and experimental toxicology.

The volume is well printed, attractively bound, and appears to be relatively free from typographical errors. The index is very complete. This is an excellent reference work, and the reviewer recommends the volume to toxicologists, pharmacologists, and those charged with the responsibility of worker protection in industry. The very complete coverage, with references, of analytical methods for each substance will appeal to laboratory workers especially.

C. Jelleff Carr

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BIOPHYSICS

Neutron Effects on Animals.

By the Staff of the Biochemical Research Foundation, Dr. Ellice McDonald, Director. The Williams & Wilkins Co., Baltimore. $3.00. viii + 198 pp.; ill. 1947.

This is a report of the various studies made by members of the Biochemical Research Foundation on the effects of fast neutrons produced by a cyclotron. The median lethal dose for rats was found to be between 60 n and 120 n in single exposures. Male rats exposed to 10 n per day for a total of 120 n all died within 60 days, whereas females survived in a few instances. Repeated doses of 1.8 n (6 times per week) reduced the rate of growth and increased the incidence of tumors, but 3 doses per week had no marked changes in the blood up to 9 months. In the more acute experiments, a lowering of the leukocyte and erythrocyte count was generally found with exposures above 17 n. Other studies involved physiological, chemical, and histological changes in the tissues of rats following neutron exposures. The changes noted were qualitatively similar to those of roentgen irradiation. Certain effects of neutrons on dogs, rabbits, and other organisms have also been reported in this book.

Titus C. Evans

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Trilinear Chart of Nuclear Species.

By William H. Sullivan; art work by Kay Benscoter. John Wiley & Sons, New York; Chapman & Hall, London. $2.50 (paper). Continuous 10½-inch-high strip. 1949.

This is a useful chart of some of the newer physical constants for nuclei; indeed, it has compressed into it an amazing amount of detail about recent values of various natural and artificially produced elements. It is unfortunate to note that many of the values for the half-lives of radioactive isotopes are not printed legibly.

Aside from this, the chart will undoubtedly have considerable appeal for workers in radioactive isotope chemistry.

L. J. MULLINS

BIOCHEMISTRY

CHEMISTRY AND USES OF INSECTICIDES.

By E. R. de Ong. Reinhold Publishing Corp., New York. $6.00. viii + 345 pp.; ill. 1948.

Technical books mirror the interests of the author or they would seldom be written. De Ong is a consulting entomologist. He has, therefore, prepared a compilation of very useful and practical facts for practicing entomologists. One of the reviewer's functions is to learn whether the contents of a book agree with the title. The word "insecticide" means to De Ong a chemical to control pests of plants, animals, or man—weed killer, bactericide, fungicide, rodenticide, or insecticide. The new word "pesticide" is a better term for so inclusive a meaning. The organization of the book revolves primarily around specific compounds, which are each described in terms of tonnage, manufacture, shipping, uses, and compatibility. Few structural formulae are given. De Ong's book may be recommended to the practical trade. It is less useful to the farmer than Stapley's book (reviewed on p. 339), more useful to those who advise farmers.

JAMES G. HORSFALL

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CHEMISTRY OF INSECTICIDES, FUNGICIDES AND HERBICIDES. *Second Edition.*

By Donald E. H. Frear. D. Van Nostrand Co., Toronto, New York, and London. $6.00. x + 417 pp.; ill. 1948.

During the six years which elapsed between the first and second editions of Frear's useful book, new pesticides appeared with remarkable frequency. DDT and other chlorinated hydrocarbons revolutionized insecticides, and the hormone weed killers opened a wholly new field. Dithiocarbamates and glyoxalidines appeared as practical new fungicides. This is an excellent source book for chemical data on pesticides and the reactions involved in their manufacture. It is not a set of instructions for use nor does it contain very many biological data, although the book does indicate some reactions that may be involved in pesticidal action. It would be of no interest to farmers, of little interest to advisors of farmers, but of considerable interest to a host of biologists and chemists.

JAMES G. HORSFALL

* * *

THE MODE OF ACTION OF ORGANIC INSECTICIDES. *Chemical-Biological Coordination Center, Review Number 1.*

By Robert L. Metcalf. National Research Council, Washington, D. C. $1.00 (paper). 84 pp. 1948.

The biologist, like the chemist, employs reagents to study reactions. The chemist uses acids and bases, oxidizers and reducers. The biologist uses foods and poisons. He accelerates his organism on the one hand, discourages it on the other.

The National Research Council through its Chemical-Biological Coordination Center is doing yeoman service for biologists in assembling the data on the relation of organic substances to biological action. As one of its activities, it is to publish reviews, Metcalf's being the first. We hope that successors will live up to the quality of the first.

Metcalf has not been content merely to describe the activity of insecticides. He has tried, meager as the data sometimes are, to discuss the dynamics of the process. He ably discusses the problems of the permeation of toxicants into insects. The reaction flasks of biologists are such organisms as cockroaches and Japanese beetles. Beyond that any similarity to chemists' problems is purely coincidental. The chemist pours his reactants together in a beaker or flask and stirs them vigorously. The entomologist must put his reagent outside the Japanese beetle and hope for penetration. Moreover, he cannot stir the reactants together. If he stirs up the innards of a beetle, he has a beetle no longer. In short, a discussion of reagents in biology must involve problems of penetration into and permeation through the body of an organism. Metcalf does this. He discusses the molecular structure of organic insecticides in terms of "toxophores" and "conductophores," in terms of the classical Overton-Meyer theory. For example, the bis (parachlorophenyl methane) moiety of DDT is apparently the toxophore and the trichloromethane moiety the conductophore. The latter assures penetration through the lipoid cuticle; the former assures death of the bug.

Metcalf's memoir is of interest almost exclusively to the frontier biologist. Those interested in biological systems and reagents for them must not miss this volume.

JAMES G. HORSFALL

* * *

CATION EXCHANGE IN SOILS. *A. C. S. Monograph Number 109.*

By Walter P. Kelley. Reinhold Publishing Corp., New York. $4.50. xvi + 144 pp.; ill. 1948.

This work represents Kelley's considered viewpoint on cation exchange in soils following many years of fruitful research. It therefore bears a strong stamp of his personality. It is, however, much better balanced than any compilation of a single individual's researches could possibly be, although it does not quite attain the coverage implied by the title. The chief defect is the very scanty treatment accorded to soil organic matter.

The first chapter deals with the history of cation exchange. It is extremely well written, and the author has been at great pains to achieve a connected narrative, not merely a series of abstracts. In Chapter 2, modern views on the nature of the materials involved in cation exchange in soils are developed, the organic matter, as noted above, being very briefly dismissed. The third chapter is devoted to cation exchange equations, and the fourth to principles of cation exchange. Many readers may prefer to take these in reverse order, since Chapter 4 contains much of the factual basis for the assumptions used in deriving the equations. The next chapters, on Exchange Capacity and Kind of Exchangeable Cation in Various Soil Types and The Determination of Exchangeable Cations, are of especial value, since much of Kelley's research has been devoted to these topics. The chapter on Cation Exchange in Relation to Soil Properties is an outline rather than an extended treatment. The last chapter deals with the identification and estimation of the clay minerals, again in outline rather than in minute detail. X-ray and thermal methods are adequately discussed, but optical methods fare somewhat badly. In general, this work can be confidently recommended to all who seek to know more of the intricacies of cation exchange and related matters as they affect soils and the crops which grow upon them.

C. Edmund Marshall

MICROBIOLOGY

Mikrobielle Symbiosen in Pflanzen- und Tierreich. *Die Wissenschaft, Band 94.*

By Traugott Baumgärtel. [Friedr. Vieweg & Sohn, Braunschweig]; J. W. Edwards, Ann Arbor. $3.75. vi + 132 pp.; ill. [1940] 1946.

The German original of this book, lithoprinted by authority of the Alien Property Custodian, was published in 1940. As the author is a bacteriologist, bacterial symbioses dominate (57 pp.), and fungus symbioses come next (30 pp.), but the book begins by considering the oldest known symbioses, those of the algae.

The term symbiosis is used in the broadest sense of the word. The author includes even sequences where one species profits from the products of the preceding flora or fauna. He also discusses true symbiosis where both forms profit, as well as the "master-servant type," and perfectly equalized cases as well as unequalized cases bordering on parasitism. A distinction is made between endosymbiosis and exosymbiosis.

After a brief discussion of the lichens, the well-known symbiosis of algae and fungi, there follows a consideration of the symbiosis of protozoa with green algae, the Zoochlorellas, or with yellow or brown algae, the Zooxanthellas. Even echinoderms and mollusks can join in such a symbiosis with algae. The resynthesis of symbiosis from the separately cultivated symbionts is discussed in some detail.

A chapter on fungus symbioses begins with a description of the two different types of mycorrhiza. These descriptions are so condensed that the uninitiated cannot follow. The account of fungus symbioses with animals begins with a description of fungus-cultivating insects, such as ants. (This extends the definition of symbiosis to a point where we can also speak of a symbiosis between man and wheat.) Quite different are the wood-boring beetles whose larvae have an abnormal development of certain parts of their intestines with these abnormal cells containing the symbiotic organisms.

The best-known example of bacterial symbiosis with plants is that of the nodule bacteria of the legumes. The attempt to explain nitrogen fixation within the nodule does not include the latest American research. Bacterial symbiosis with plant-eating beetles is described in some detail in so far as the morphology of the beetles is concerned, but the role of the bacteria is not mentioned, though in some cases these bacteria can be obtained in pure culture. The same criticism applies to the descriptions of the bacterial symbioses with bugs, scales, aphids, and ants. The book gives details of the mode of transmission, but does not mention the role of the bacteria and their usefulness to the insects. Examples are given of luminescent bacteria causing luminescence of various marine animals.

The symbiosis of bacteria with mammals is exemplified by a description of the bacteria of the intestine of the horse. Our latest knowledge of the ruminant flora obtained by cutting a "window" into the ruminant has been acquired since this book was published. The extensive chapter on the symbiosis of bacteria with man stresses rather one-sidedly the *Lactobacillus bifidus*, but fails to mention the formation of vitamins by the intestinal flora proved by the application of certain sulfa drugs that kill the intestinal bacteria.

The book is written interestingly in a semipopular vein. Because it was written 10 years ago, it lacks the latest developments in this science. Nevertheless, it is stimulating for the reader who works in this borderline field.

Otto Rahn

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Germ-Free Life Studies. *Lobund Reports, Number 2, February 1949.*

Edited by James A. Reyniers. The University of Notre Dame, Notre Dame, Indiana. $2.50 (clothbound); $1.75 (paperbound). viii + 162 pp.; ill. 1949.

No. 1 of the Lobund Reports was reviewed in Q.R.B. 23:75. The present number contains 3 papers: Rearing Germ-Free Chickens; Some Observations on Germ-Free Bantam Chickens; and The Need for a Unified Terminology in Germ-Free Life Studies; all of them by J. A. Reyniers, P. C. Trexler, R. F. Ervin, M. Wagner, T. D. Luckey, and H. A. Gordon.

The first paper reviews previous attempts to rear germ-free chickens, and also gives a great deal of detail on the specialized equipment and methods used by the present authors, involving the sterilization of fertile eggs and the use of a sterile diet for the chicks. The second paper deals with the results of the germ-free growth of poultry. The Rose Comb White Wyandotte Bantam chicken is preferred because of its small size. This variety was reared through its entire life cycle and into a second generaton under aseptic conditions on an autoclaved diet. Growth was reasonably good, but egg production was sporadic and hatchability was poor. Compared to normal controls, there were differences in the development of the lymphoid system and intestines. The fat, ash, vitamin content, and moisture of the liver were essentially normal. The brain showed a higher potassium content. The vitamin content of the ceca was high, despite the absence of an intestinal flora. Antibodies against certain bacterial antigens could be demonstrated in low titer, probably owing to dead bacteria in the food. The third paper discusses the desirability of having a uniform terminology in this experimental field. No very definite recommendations are made, although the authors seem to incline toward the use of the general term *gnotobiotics* (Greek, γνωτός-known, βίος-life), which leads to such derivative terms as *gnotobiote* for an animal free of contamination (or associated only with known microorganisms).

Like the previous number, the publication will be indispensable to those working in the same field and of great collateral interest to workers in animal nutrition in general. The editors hope that eventually persons in other institutions may submit contributions. In view of the highly specialized methods and equipment required, it may be doubted whether the field will ever become a highly active one.

WALTER C. TOBIE

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THE NATURE OF THE BACTERIAL SURFACE. *A Symposium of The Society for General Microbiology, April, 1949.*

Edited by A. A. Miles and N. W. Pirie. Charles C. Thomas, Springfield, Ill. (printed in Great Britain). $3.00. viii + 179 pp. + 12 plates. 1949.

The depiction of the bacterial cell as a bag of enzymes has been criticized repeatedly for ignoring other contents of the cell and their functional integration. Most discussions of biological surfaces have, however, degenerated into uninformed speculation on topics like specific permeability as a metabolic regulation, concerning which we have practically no concrete experimental data. This symposium has steered clear of such speculations, for the most part, and is concerned primarily with the discussion of factual information on the composition, structure, and function of bacterial surfaces. Despite a prefatory apology by N. W. Pirie for the omission of certain aspects of bacterial surfaces, the contributors represent a wide variety of viewpoints: chemistry, immunochemistry, morphology, bacterial virology, biophysics, and genetics.

Immunochemical studies bearing on bacterial surfaces are reviewed by W. T. J. Morgan, A. A. Miles, and E. T. C. Spooner. The methodology of this approach is carefully studied by these authors, and their conclusions concerning the inadequacy of various isolated criteria for the surface role of immunochemically identified components are well taken. These authors have also contributed a useful discussion of the difficulties of defining the boundary between the cell proper and its environment, part of which—e.g., capsular secretions—may be produced by the cell. A related tack is amplified by Harriett E. Taylor in a review of recent work on the pneumococcus transformations. M. Stacey's interpretation of the transformation as a "starter" effect of the capsular polysaccharide during its enzymatic synthesis is discussed in critical detail.

The osmotic functions of the bacterial surface are taken up by P. Mitchell. A model hypothesis for the accumulation of amino acids is developed for glutamic acid on the basis of a surface envelope consisting of a lipid layer 50 Å thick. The amino acid is converted into lipid-soluble glutamine at the outer surface, and is hydrolyzed to glutamic acid again at the inner interface. Many workers have postulated such biochemical cycles as accumulation mechanisms. However, this hypothesis is clearly inapplicable to those streptococci which require glutamine as a growth factor.

M. Stacey reported the studies by his colleagues and himself on the nature of the Gram-staining complex of Gram-positive bacteria. T. F. Anderson gave a detailed account of the factors involved in adsorption of bacteriophage to the bacterial surface, with new data on the kinetics of activation of certain phages by adsorption cofactors (tryptophane). As commented by A. Felix, the simplified picture of adsorption as a "simple steric fitting of complementary rigid surface structures" is replaced by "dynamic processes involving enzymic steps of degradation and synthesis." But to infer that phages are "indigenous products of the bacterial cell and not separate viruses" is to ignore a large body of evidence for their exogenous origin, some of which is cited by Anderson. The volume closes with an account by A. Pijper of his sunlight-darkfield observations on the functions of bacterial flagella. His heterodox views have excited considerable discussion in this volume, and elsewhere.

Each paper is accompanied by a paraphrase of the discussions, which are very lively and true-to-life. The discussions and the photographic illustrations are a very valuable part of the book. The volume is well made up, and essentially free from typographical errors (except precipitin for precipitinogen, p. 130). The book should be read by every serious student of bacteriology and cell physiology, and it may be hoped that this timely discussion will help to focus more intensive examination on a group of problems which has suffered, in the past, from too high a proportion of speculation to experiment.

J. LEDERBERG

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PLANT VIRUSES. *Second Edition. Methuen's Monographs on Biological Subjects.*

By Kenneth M. Smith. Methuen & Co., London. 6s. x + 78 pp. + 8 plates; text ill. 1948.

The author of this pocket-sized treatise is one of the world's best qualified persons to perform the difficult task of summarizing modern knowledge about plant viruses. In a field where the application of technics of protein chemistry and physics has brought spectacular advances in our knowledge of the physical nature of viruses, there is great need for the maintenance of a broad and integrated biological viewpoint. Smith has done this, giving due attention to the pathological physiology of the virus-infected plant, in addition to presenting a concise summary of the modes of transmission of plant viruses. The chapter on viruses in relation to their insect vectors reflects the extensive knowledge and experience of the author in that particular area. The control, serology and classification of plant viruses are covered briefly but well. The pioneer work of Vinson from 1929 to 1933 on the chemical isolation and purification of tobacco mosaic virus was followed by the isolation of the same virus in paracrystalline form by Stanley and the determination of its macromolecular nature. The discovery of the nucleoprotein structure of plant viruses by Bawden and Pirie was a great step forward. A tremendous surge of activity followed in both the animal and plant virus fields. This second edition (1st ed., *Q.R.B.*, 11:106) of *Plant Viruses* has been entirely rewritten to include many of these important developments. The final chapter presents some of the theories concerning the origin of viruses. Such an abbreviated account of the plant virus field must of necessity omit much of importance. Nevertheless, I was impressed by the amount of material included in so few pages and the balanced scientific manner of its presentation. This little book presents in an interesting way the broad outlines of the plant virus field.

M. W. WOODS

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HEALTH AND DISEASE

REVISTA DA ASSOCIAÇÃO MÉDICA DE MINAS GERAIS. *Vol. 1, No. 1, August 1949; No. 2, December 1949.* Pp. 1–229.

Edited by Aulo Pinto Viegas, Hilton Rocha, Lucas M. Machado, E. Livio Renault. Associação Médica de Minas Gerais, Belo Horizonte. Annual subscription, Cr$ 60.00 or U. S. $5.00; single numbers, Cr$ 20.00. Published four times a year.

Although it is primarily a medical journal for original papers in the Portuguese language, this new journal carries some papers in English, e.g., in No. 2: BCG Vaccination in Rio de Janeiro (J. Feldman); Hemosedimentation Test in Obesity (A. P. Viegas). There is a section in each issue of a more general sort, and headed "De Rebus Pluribus."

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MEDICAL DISORDERS OF THE LOCOMOTOR SYSTEM INCLUDING THE RHEUMATIC DISEASES.

By Ernest Fletcher. The Williams & Wilkins Co., Baltimore. $11.00. xii + 625 pp. + 1 chart; text ill. 1947.

The author of this book is a British physician who presents a major interest in the art of medicine as applied to arthritis. He has extended his considerable personal abilities by calling upon 9 contributors in special subjects. The scope of the text has thus been extended to the medical aspects of the locomotor system.

The contents may be very approximately divided as follows. The first 100 pages consist of introductory subjects, which include a classification of rheumatic conditions, examination of the patient, physiology, and anatomy. The next 340 pages contain a discussion of arthritic conditions. This is followed by about 150 pages devoted in the main to allied locomotor conditions. The remaining pages contain a chapter on physical therapy, and an appendix containing empirical aids to diagnosis and treatment of the several diseases. Each of the 35 chapters is followed by a bibliography which draws extensively from American as well as British sources.

A biologist will observe that this book is not directed toward his ordinary interests, but rather that it stresses the empirical and clinical aspects of musculo-skeletal diseases. Pure science is significantly minimized in favor of clinical and practical discussions. Yet a biologist who is interested in arthritis can glean historical and research references from the bibliographies, while having his clinical understanding of the several rheumatic diseases extended through relatively pleasant reading. The text gives no information on the recent trend toward hormone research and therapy as applied to arthritis. In short, a biologist with clinical leanings will find this book of interest; others will benefit only slightly from its message.

NEPHI K. KEZERIAN

CARDIAC CATHETERIZATION IN CONGENITAL HEART DISEASE: *A Clinical and Physiological Study in Infants and Children.*

By André Cournand, Janet S. Baldwin, and Aaron Himmelstein. The Commonwealth Fund, New York; Geoffrey Cumberlege, Oxford University Press, London. $4.00. viii + 108 pp.; ill. 1949.

Cardiac catheterization has only recently become an accepted procedure in the diagnosis of congenital heart disease. Progress has been rapid since the use of this technique in the study of auricular septal defects was introduced 5 years ago. The groups working respectively under Cournand, Bing, and Dexter have been outstanding contributors to the field, and the material in this short monograph from Cournand's group is to be considered authoritative. Although the method of study may come to have wider application in normal cardiac and pulmonary dynamics, in pharmacology, and in acquired heart disease, its value in the study of congenital cardiac anomalies is already firmly established.

In brief, cardiac catheterization consists of passing a flexible venous catheter (under electrocardiographic and roentgenologic control) into the right heart chambers and pulmonary artery for the purpose of sampling blood and obtaining blood pressures. In patients with septal defects, the left heart also may be available for study. When simultaneous expiratory gas samples, right heart blood (mixed venous blood), and arterial blood samples are obtained, it is possible to calculate the cardiac output by means of the Fick principle: oxygen consumption divided by arteriovenous oxygen difference equals cardiac output. Variations of the Fick formula make it possible to estimate the magnitude of cardiac shunts, and of pulmonary flow when this differs from systemic flow.

The opening section of the book is a concise outline of the physiological methods, techniques, and equipment used in cardiac catheterization. The roentgenographic appearance of the catheter in the heart and the characteristic blood pressure curves are well illustrated; necessary calculations are described; and the importance of the electrocardiograph in avoiding dangerous arrhythmias is stressed. Physiologists will perhaps be disappointed by the pressure curve artifacts that may be introduced by the use of a long catheter, but the basic significance of the records cannot be denied. The second portion of the book comprises 17 case presentations encompassing a wide variety of single and multiple cardiac defects. The lack of supporting autopsy material is unavoidable and not of a serious nature. The authors are to be congratulated on the diagrammatic clarity and completeness of their clinical studies and on their thoughtful analysis of the data.

E. CONVERSE PEIRCE, 2ND

EPILEPSY. *Psychiatric Aspects of Convulsive Disorders. Proc. 36th Annual Meeting, Amer. Psychopathol. Ass., Held in New York City, May 1946.*

Edited by Paul H. Hoch and Robert P. Knight. Grune & Stratton, New York. $4.00. viii + 214 pp.; ill. 1947.

These 15 papers cover a wide variety of material, ranging over the historical, social diagnostic, clinical, and medical aspects of epilepsy. The subject matter includes the genetics of epilepsy (Kallman and Sander), the prevalence of epilepsy (Malzberg), its social implications and management (Collier), antisocial aspects of epilepsy (Foxe), personality of the epileptic (Piotrowski), differential diagnosis of epilepsy (Diethelm), diagnostic testing in convulsive disorders (Mayman and Rapaport), the psychopathology of epilepsy (Mittelman), some psychopathological aspects of organic brain damage (Hock), experimental production of epilepsy in animals (Kopeloff and others), electroencephalography in epilepsy (Jasper), and maternal nutritional deficiency and the incidence of sound-induced convulsions in young albino rats (Patton). The volume stresses the psychiatric aspects of epilepsy, dealing not only with the disease process but also with the general well-being of the epileptic patient. Emphasis is placed on the psychiatric help and counsel which an epileptic patient needs besides the medical treatment. The general clinical approach, rather than research, is stressed.

SAMUEL LIVINGSTON

EPILEPSY AND CONVULSIVE DISORDERS IN CHILDREN. *McGraw-Hill Series in Health Science.*

By Edward M. Bridge. McGraw-Hill Book Co., New York, Toronto, and London. $8.50. xiv + 670 pp. + 12 plates; text ill. 1949.

Bridge's work on epilepsy and convulsive disorders in children represents a milestone in medical literature. The presentation of the subject is such that it is an invaluable and indispensable reference for the physician, student, nurse, social worker, or layman who seeks knowledge and orientation about convulsive disorders in children. The treatment of the subject is unique in many respects. Emphasis has been placed first on the underlying forces that give rise to the symptoms. The various manifestations of epilepsy are treated from a broader viewpoint than description alone. Treatment is scattered throughout the presentation; in particular, as part of the discussion of the various manifestations: major convulsions, minor seizures, etc. The importance of psychosomatics as a basic concept in the treatment of convulsive disorders is stressed.

The wealth of material in this book is the result of careful and numerous scientific studies and analyses carried out over a period of years by the author and his associates on 742 children treated at the Johns Hopkins Hospital Epilepsy Clinic, integrated with the pertinent literature and medical research on epilepsy. Bridge probes the problem of convulsive disorders in children not by searching for a single cause but by evaluating the relative importance of (a) heredity, (b) structural defects in the brain, (c) physiological disturbances, (d) personality maladjustment, and (e) environmental strains in producing the symptoms of recurrent seizures. I strongly recommend that this book be read by all who are concerned either socially or medically with the problems of convulsive disorders in children. It fills a gap which has existed for many years.

SAMUEL LIVINGSTON

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L'ALLERGIE TUBERCULEUSE CHEZ L'HOMME. *Étude de l'Allergie au Cours des Principales Localisations de la Tuberculose de l'Homme, ainsi qu'au Cours de l'Infection Tuberculeuse Latente. Le Mecanisme de l'Allergie Tuberculeuse. Le Retentissement de l'Allergie sur l'Évolution des Lésions Tuberculeuses. Allergie et Immunité Antituberculeuse. Collection de l'Institut Pasteur.*

By Georges Canetti. Éditions Médicales Flammarion, Paris. 225 fr. (paper). 338 pp.; ill. 1946.

The main body of this studiously compiled, inexpensively equipped, and somewhat diffusely organized monograph consists of a comprehensive review of controversial theories and inconclusive data on allergic phenomena in clinical tuberculosis. In this part of the book, the author's approach is generally on the conservative side, impartial, and always free of speculative assertion. In the concluding section, the author discusses his own views on the immunobiological and preventive aspects of the disease. Particular emphasis is placed on the inseparable interrelationship of allergic oversensitivity and immunity to reinfection. However, neither allergic nor immunological mechanisms are believed to play an essential part in the development of reinfection tuberculosis, although the available information about the responses of allergic and non-allergic persons to controlled gradations of exposure is considered inadequate. The most important causative elements are seen in the massiveness of exposure and in extreme deficiencies in the degree of natural resistance. The significance of genetically determined variations in natural resistance to tuberculosis is stressed, irrespective of a certain vagueness in defining the basic concept of natural resistance.

FRANZ J. KALLMANN

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MYCOSES AND PRACTICAL MYCOLOGY. *A Handbook for Students and Practitioners.*

By N. Gohar; with a foreword by Sir Philip Manson-Bahr. The Williams & Wilkins Co., Baltimore. $6.00. xii + 234 pp. + 4 plates; text ill. 1948.

Gohar's *Mycoses and Practical Mycology* is a new and useful addition to the growing list of handbooks on a subject of increasing importance to medicine. It presents a thoughtful discussion of theoretical as well as practical aspects of medical mycology. The roles of soil and decaying vegetation as reservoirs of fungi which may be normally saprophytes but can, under suitable circumstances, become pathogens is briefly but clearly stated.

Nearly half the book is devoted to epidermophytosis and other abnormalities of the skin or hair, in a few of which a fungous etiology is doubtful. The clinical aspects of various types of dermatophytosis, evolution of the lesion, appearance of the fungus, and treatment are fully discussed. A clinical classification of material is followed for the most part, although, as the author points out, there is some overlapping of mycological and anatomical groupings. The discussion of each mycosis is based upon definition, history, symptoms, diagnosis, and treatment. The author may not have intended this small volume as a reference book, but its usefulness would have been increased if citations to some of the important literature had been given.

It is regrettable that a book which will be accepted as authoritative is marred by a number of errors. After defining the blastomycoses as diseases due to infection with true yeasts, the author follows Dodge in classifying *Coccidioides immitis* as an ascomycete and discusses coccidioidomycosis as a blastomycosis. It is generally recognized, on the contrary, that *Coccidioides* is a phycomycete. Similarly the term ascus is misused in connection with *Histoplasma*, *Zymonema* (*Blastomyces*) and *Paracoccidioides* (which is erroneously related to *Coccidioides* rather than to *Zymonema*). The author apparently overlooked the prevalent benign type of coccidioidomycosis, i.e., "Valley fever," in stating that spontaneous cure is exceptional. "Torula meningitis" (cryptococcosis) and "Busse-Buschke's blastomycosis" are discussed as different diseases with different etiologies, although they are generally accepted as manifestations of one disease and have the same etiology. Similarly, *Monosporium apiospermum* and *Allescheria boydii* are presented as 2 different fungi although they are known to be growth forms of a single fungus. Numerous other departures from modern and accepted terminology and synonymy, particularly among the dermatophytes, might be cited. The history of actinomycosis is well told, but an old error is perpetuated by erroneously labeling as *Actinomyces bovis* a culture of an aerobic *Streptomyces*. Regardless of whether *Actinomyces bovis* or *A. israel* is accepted as the valid name for the etiologic agent of human actinomycosis, the name *A. bovis* cannot be used properly for an aerobic *Streptomyces.* It is stated that histoplasmosis (which actually is widely distributed over the world) is found only in the United States and Central America, although 2 pages later a case from Java is mentioned. Although their generally accepted nonmycotic etiologies are mentioned, 10 pages are devoted to a discussion of sprue and 5 pages to pinta. The last chapter presents a useful summary of fungicides, prescriptions, culture media, and poisonous fungi.

C. W. EMMONS

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SCIENCE VERSUS CANCER. *Sigma Introduction to Science 2.*

By I. Berenblum. Sigma Books, London. 6s. 116 pp. + 8 plates. 1946.

Fowler in the *Concise Oxford Dictionary* defines *beautiful* as "morally or intellectually impressive, charming or satisfactory." This reviewer feels Berenblum's *Science Versus Cancer* is best described as beautiful. In 9 polished chapters: (The Nature of the Disease, its Frequency, the Influence of Heredity, the Influence of Environment, Diagnosis, Treatment, Cancer Research [2 chapters], and Retrospect and Prospect) the author presents the cancer problem in a manner which reveals him as a teacher, researcher, and a sensitive and understanding man. Written in non-technical terms for the layman, it is a model for the scientist who wishes to present to the curious citizen a view of this special field of interest. It can well serve the young practitioner as a guide in discussing the cancer problem with patient or family. Medical students could profit much by spending this hour with Berenblum. No biologist could fail to profit from reading *Science Versus Cancer.* The book has a glossary of terms and is adequately indexed.

M. C. SHELESNYAK

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ATOMIC MEDICINE.

Edited by Charles F. Behrens. Thomas Nelson & Sons, New York, Edinburgh, and Toronto. $7.50. xiv + 416 pp.; ill. 1949.

The problem of presenting the field of nuclear physics to the student of medicine is a difficult one because of its extent, its numerous disconnected applications, and the inadequate training in basic sciences which is such a serious and outstanding defect in our medical education today. The discrepancy between present training given medical personnel and the scientific preparation required for proper application of the field of nuclear physics to medicine is an excellent illustration of this important failure of our medical schools. It is not clear whether this is adequately appreciated in the medical profession. From this it follows that a book on *Atomic Medicine* has a difficult goal to attain from the outset. It is obviously not possible within the confines of one book to provide an adequate education in atomic medicine for the medical man. By trying to cover the entire field Behrens' book fails to accomplish this aim in almost every phase of atomic medicine which it takes up. However, for those who wish a general survey of the whole subject it does give an easily read account of large portions of the field. This is provided in a generally uncritical fashion, without benefit of many data or extensive evidence. The material is presented by 20 contributors who give a discontinuous account containing many long repetitions. For an introduction to the field the book may be useful, although it is rather long for this purpose. At $7.50 it is overpriced, in my opinion.

FREDERICK W. BARNES, JR.

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MALARIA IM KINDESALTER. *Bibliotheca Paediatrica, Supplementa zu Annales Paediatrici, Fasc. 47.*

By Albert Eckstein. S. Karger, Basel (Schweiz) and New York. S. fr. 14.00 (paper). viii + 119 pp.; ill. 1946.

This strictly clinical monograph reflects the views of a prominent European clinician following a score of years of close contact with malaria in Turkey, where the disease has been common for centuries. The monograph has a somewhat wordy but methodical table of contents, and is divided into 4 large sections: an Introduction, a section on Prophylaxis, an extensive discussion of Clinical Diagnosis, Symptomatology and Pathology, and finally, a special section on the Care and Treatment of Childhood Malaria. The author feels that because of the frequent deviation of clinical malaria in children from the classical picture of adult malaria described in textbooks, the use of the term "childhood malaria" is justifiable. The Introduction is largely a discussion of the author's experience with malaria in pediatric clinics in Germany and especially in Turkey, and to an explanation of his reasons for writing the monograph. The author reports a mortality rate of 40% among malaria cases in children, 8.8% of which were in nursing babies, 18.6% among infants, and 12.4% in older children, for the years 1931–34.

The section on Prophylaxis considers prevention through anti-malarial campaigns, including mosquito eradication and suppressive medication as well as the elimination of clinical malaria after it has developed. The relative usefulness of the several available malariacidal drugs when applied to childhood infections is discussed.

In the discussion of clinical and laboratory diagnosis, proper emphasis is given to the need for adequate thick-film examination of blood, an especially important procedure because in children the symptomatology may and often does present manifestations of protean nature. This is especially true of the febrile curve, a notoriously poor diagnostic criterion for this age group.

The author describes a series of 14 cases, out of some 200,000 observed, in which what he felt was true congenital infection was demonstrable—an infection of the fetus having resulted from transplacental contact following injury to the placenta during extreme malarial paroxysms. The real number of such occurrences is, the author believes, actually much greater than has been supposed. Thus, a prophylactic program during pregnancy is highly indicated, for in addition to congenital infection, the danger of abortion is an ever-present threat to the health of mother and child. To combat this, Eckstein prescribes the use of atabrine or other essentially non-toxic antimalarials.

Clinical malaria of childhood is discussed under 3 sub-headings: nursing infants, young children, and older children. The first of these presents an especially atypical symptomatology. The paroxysms frequently do not include chills and fever, the rigors usually seen being replaced by "febrile cramps." If fever is seen at all, it is usually not very high. Although this suggests a low reaction of the infant to the toxic by-products of the parasitemia, appearance of splenomegaly is very common. Another frequent characteristic of this age group is dyspepsia and enteritis.

A frequent complication of malaria in young children is dystrophy. This closely resembles nutritional deficiency dystrophy of similar age groups. Eckstein says that among such cases, fever and splenomegaly may be slight or entirely absent, and the growth rate is so depressed that dwarfism is common in chronic cases. The connection of these symptoms to malaria is shown in the miraculous response following specific therapy.

Also included is a comprehensive consideration of the occurrence of liver cirrhosis and kidney damage among cases of childhood malaria. No connection was seen in the size of the spleen and the liver. In some cases, cirrhosis occurred in the complete absence of splenomegaly and vice versa. Malariacidal compounds, in the author's experience, had little or no effect in reducing the size of enlarged livers. Nephrosis seemed to be a frequent sequel of quartan malaria among children, but nephritis showed no connection whatever to any type, the former responding to antimalarial drugs, the latter not being affected. Carbohydrate metabolism was frequently upset in that blood and CSF sugar were found often elevated in severe cases.

Almost one-fourth of the monograph is devoted to the effect of malaria on the central nervous system of children. The various complications are classified into: (A) Prodromal Signs of the Coma Stage; (B) The Malarial Coma, with 8 subtypes which the author recognizes; and finally (C) The Sub-Acute Types of CNS Involvement, including 7 clinical subtypes. All of these forms of malaria are exhaustively discussed. Some of the material is repetitive and verbose.

The treatment of malaria in childhood is similar to that in the adult except for the difficulty in obtaining the cooperation of the child in taking distasteful drugs, so the author suggests the use of parenteral therapeusis wherever possible. A simple treatment regimen is outlined for both atabrine and quinine. The suggested use of plasmochin should perhaps have been accompanied with caution concerning its toxicity.

Although this monograph might have well profited from condensation, the information given is worthwhile and offers valuable pointers to the pediatrician.

ALAN C. PIPKIN

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PRINCIPLES OF INSECT PATHOLOGY. *First Edition. By Edward A. Steinhaus. McGraw-Hill Book Co., New York, Toronto, and London.* $8.00. xii + 757 pp. 1949.

Scarcely 10 years have elapsed since the study of insect physiology made its debut as a discrete discipline. It was heralded by the appearance of Wigglesworth's *Principles.* During the intervening period this offspring of entomology and physiology has waxed strong. Nonetheless, it is apparent that lacunae in our knowledge of the physiology of the normal insect far exceed the known framework. It might seem at first glance, therefore, that a book devoted to the abnormal physiology of insects, the functional, chemical, and structural alterations resulting from disease or injury, is premature. Yet a perusal of Steinhaus' signal work reveals that this is not the case. The field of insect pathology has heretofore occupied a relatively obscure position, largely because of its diffuseness; yet it is a field of endeavor which has claimed the attention of eminent scientists, among them Pasteur, for over 100 years. This volume introducing the science of insect pathology does yeoman service in concentrating an impressive volume of scattered and seemingly unrelated facts. The skill with which the material has been organized to produce a coherent treatise is commendable.

Although intended primarily as a textbook, this book fills the need for a reference work, too. It is composed of 14 chapters and has extensive author and subject indices. After an introductory chapter in which definitions are set forth and the historical background and techniques of insect pathology are discussed, the subject matter is divided as follows: mechanical, physical, and chemical injuries; diseases of nutrition and metabolism; extracellular microbiota of healthy insects; intracellular microbiota; infection and epizootiology; resistance and immunity; symptoms and pathologies; bacterial infections; fungus infections; virus infections; protozoan infections, nematode infections, applied insect pathology, and biological control. The book is very well written and profusely illustrated.

Extensive references at the ends of chapters are especially helpful. This book should fulfil not only its purpose as an introduction to the study of insect pathology and a reference work but should also act as an incentive to potential workers in the field.

V. G. Dethier

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Mosquitoes and their Relation to Disease. *Their Life-History, Habits and Control. Fifth Edition. Brit. Mus. (Nat. Hist.)—Econ. Ser. No. 4.*

Printed by order of the Trustees of the British Museum by William Clowes and Sons, London and Beccles. 6d. 17 pp. 1949.

PSYCHOLOGY AND ANIMAL BEHAVIOR

Army-Ant Life and Behavior under Dry-Season Conditions. *3. The Course of Reproduction and Colony Behavior. Bull. Amer. Mus. Nat. Hist., Vol. 94: Art. 1.*

By T. C. Schneirla. $1.00 (paper). Pp. 1–82 + 2 plates; text ill. 1949.

On the Relationship of Social Behavior to Pigmentation in Tropical Shore Fishes. *Bull. Amer. Mus. Nat. Hist., Vol. 94: Art. 2.*

By C. M. Breder, Jr. 50 cents (paper). Pp. 83–106 + 8 plates; text ill. 1949.

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General Psychology. *Second Edition.*

By W. J. H. Sprott. Longmans, Green & Co., London, New York, and Toronto. 14s. x + 467 pp. 1947.

An inclusive exposition of basic psychological phenomena and processes, as well as of various frames of reference in psychology, is offered in this revised edition. The usual gallery of topics in general psychology is presented, along with such chapters, strange to American students, as those on Other People (separate from Social Environment) and The Field of Consciousness (separate from The Perceptual Field), as well as the concluding one, The Relation Between Body and Mind.

The work as a whole is nonexperimental in tone, and expository in the manner of a text in metaphysics or epistemology. It is freighted with the concepts and metaphysical conjectures that characterize the introspectionist, philosophical strain of much traditional British academic psychology. Interestingly enough, however, such emphases in the areas of perception, consciousness, and the thought processes seem to make portions of this text more relevant for an appreciation of the latest developments in perceptual theory and projective psychology in this country than most American textbooks in general psychology. At the same time, however, the reader is left with an impression that psychology has but lately emerged from philosophy, and that the adequacy of its hypotheses can be tested by mental operations based on the private experience of the "psychologist." This impression is not weakened by the author's inclusion of the speculations and fantasies of Jung, Melanie Klein, and Gerald Heard in his exposition.

Unlike American textbooks, the topic of psychical research is defined and discussed in the most speculative manner, with only casual reference to experiments. In this connection it is remarked that "psychologists should not shrink from penetrating the obscurities of psychic research; there is sufficient evidence to invite investigation, and the position of an ostrich with its head buried in the sand is neither dignified or helpful" (p. 288). We are not, however, told what "sufficient evidence" is, nor on the other hand why "dignity" and "helpfulness" are crucial in the conduct of scientists. A versatile receptivity to a variety of theoretical viewpoints and possible hypotheses is indispensable for the growth of understanding, prediction, and control. But if intellectual appreciation and philosophic appraisal luxuriate at the expense of empirical verification, an exposition of psychology can hardly command the respect that the labors of its researchers and practitioners today so justly deserve.

Erling Eng

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General Psychology. *Principles and Practice.*

By John Edward Bentley. J. B. Lippincott Co., Philadelphia, London, and Montreal. $3.50. xviii + 389 pp. + 5 plates; text ill. 1947.

This book is the precipitate of experience in teaching introductory psychology to nurses. The material is divided into 5 sections: The Organic Basis of Human Psychology, Sense Activity and Sense Experience, Learning, Personality Adjustment, and Applications of Psychology to Nursing. Basically, the book is little more than an outline of the various topics in general psychology. Sensory, motor, and neural mechanisms are presented in some detail, in accordance with the author's belief in the importance of the organic basis of all behavior. In addition, thumb-nail characterizations of the various "psychologies" are included, as well as a trivial, misleading section on Clinical Psychology. On the whole this is an unfortunate book, both for the reputation of psychology, and for the understanding of students. Typical passages like the following disclose an unconscionably superficial understanding of personality structure:

> "There is always the danger of the normal man or woman faltering, failing, falling from the path of normal behavior, for the line of demarcation between normal

and morbid behavior is very thin. At any moment the normal man may fail and become a part of the army of misfits, the mentally sick, and flounder in his normal tasks, swelling the growing tide of human failures. This danger is well illustrated by the fact that the annual increase of mental patients in our hospitals has risen to four and one-half per cent and the rate is rising" (p. 267).

It is difficult to recommend such a misleading and poorly-written book for any class in psychology.

Erling Eng

Aids to Psychology. *Third Edition.*

By John H. Ewen. Baillière, Tindall and Cox, London. $1.75. viii + 192 pp. 1948.

This small book has been written as a study aid for British students preparing for a "Diploma in Psychological Medicine." It attempts to provide a comprehensive but concise review of the concepts, principles, laws, and classificatory schemes contained in the academic psychology usually encountered by such students. Some idea of the frame of reference of this psychology may be gained from the following selection of chapter headings: Body and Mind; Cognition, Conation, Affection; Instinct; Imitation; Belief; Sentiment; Complex, Dissociation, Types of Thinking; Illusion, Hallucination. Most generously reviewed and expanded are the concepts and classifications of McDougall (all 14 of his "major instincts" are discussed), accompanied by passing references to such worthies of an earlier day as Stout, Ward, Ladd, and James.

Characteristic of the era of psychology from which the views summarized in this book have descended are statements like the following:

> "Mental dispositions are unconscious factors connected with consciousness" (p. 38).
>
> "The food-seeking instinct is exhibited in various forms, and is variously specialized. Its emotion is gusto. The impulse to wander in search of food differentiates animals from plants" (p. 71).
>
> "Emotion is a mode or quality of experience. The emotions are varieties of emotional experience. The emotional qualities, when functionally considered, are subjective or significant of the nature of the subject" (p. 124).

Outside the special audience for which it has been tailored this book is likely to occasion scant interest because of the outworn taxonomic approach to "mental phenomena" that it so largely exemplifies.

Erling Eng

Problems of Human Adjustment.

By Lynde C. Steckle. Harper & Bros., New York. $3.00. xii + 351 pp. 1949.

This book is designed as a "text for courses in mental hygiene, personal adjustment, and personality development." Its central theme is that man is primarily an emotional being, subject to the atavistic controls of his formerly necessary, but now relatively useless, physiological preparatory adjustments. These responses are effective through the "old brain" and, when not fully recognized and controlled by the "new brain" of modern man, lead to maladjustment. While this anatomical and evolutionary pattern is inevitable and leads the author to be rather pessimistic in his outlook for the species at some places in the book, his general view is that understanding and the exercise of intelligence will make successful living possible. This faith in the possibility of intellectual control over the emotional patterns of response is carried through consistently. In discussing courtship, for example, Steckle says: "If your boy or girl friend is constantly on the watch for signs that your affection is wanting, if he or she seems to feel that you are not to be trusted out of sight, break it off." The assumption that this is easy appears unrealistic. The consistent faith prevails through a discussion of religion that rather cavalierly disposes of the whole of that problem as myth and superstition. It resolves into an ethical philosophy very like that of the Golden Rule.

The concept that intelligence or "new brain" offers the complete solution to life's problems marks this book as rather less than modern in its psychotherapeutic content. It pays little heed to the usefulness of the attitudinal changes that appear in the interview, for example, though this technique is dealt with briefly in the last chapter. Very little is said about the powerful factors of rapport and transference. The book is largely mechanical and not very human.

Paul V. Lemkau

More about Psychiatry.

By Carl Binger. The University of Chicago Press, Chicago. $4.00. xiii + 201 pp. 1949.

This little book is a compilation of several articles that Binger has written for various journals, medical and lay. It touches on a variety of subjects: psychosomatic disorders, mental health, anxiety, what can be learned from medical history, choosing a mate, psychoanalysis, and so on. The author's style is easy and will ingratiate itself with the lay reader. Furthermore, the material he talks about is factual, presented so that the reader will get an authentic account. Some of these chapters have been read widely already, since they appeared in national journals, and it is rather pleasant now to have this group of informal essays for general distribution in book form. There is a considerable bibliography for each chapter.

Wendell Muncie

GUIDING HUMAN MISFITS. *A Practical Application of Individual Psychology. New and Revised Edition.*

By Alexandra Adler. Philosophical Library, New York. $2.75. 114 pp. 1948.

Alexandra Adler is the daughter of Alfred Adler, a Viennese psychologist noted for having split with Sigmund Freud in postulating inferiority feelings as the fundamental conflict in personality disorders. She has written this short book for the lay public, apparently to present her father's thesis in popular form. In so doing she has set aside considerations of more involved psychodynamics and has made the field of psychiatry appear phenomenally simple.

HELEN ARTHUR

GUIDANCE POLICY AND PRACTICE.

By Robert Hendry Mathewson. Harper & Bros., New York. $3.00. xiv + 294 pp.; ill. 1949.

The presentation in this volume differs from that of the other recent publications in that its primary aim is to formulate a framework which will fit all guidance activities into the contemporary pattern of our social and industrial structures. Since the author wishes to present the theoretical implications of guidance, he writes only in terms of the philosophical, sociological, and educational connotations of the guidance movement rather than in strictly scientific and technical terms. He would like to bring some semblance of law and order into the thinking of the educators and administrators who are responsible for organizing and promoting programs in a field which in its brief history has had something in common with Topsy's growth.

An educator attempting to fit the guidance field into such a sociological perspective faces the dilemma of the somewhat dichotomous nature of guidance. He may take as his primary point of departure the special attributes and aptitudes of the individual, and the world into which he must fit as a secondary concern; or he may start with the needs of the social structure, and attempt to have the guidance process serve social ends. Mathewson has tried to knit the two phases together and to show that in actuality they are not divorced. "The kind of society," he states, "which provides maximum freedom and opportunity for individual development can be neither individualistic anarchy nor a tyrannical despotism. The solution sought is a constantly adjusting dynamic reciprocation of individual and social interest. Thus the foremost social imperative in a democracy is to provide the type of education on the one hand which will make its citizens wise choosers and purposers, and the type of society on the other in which such choosers and purposers can harmoniously develop." Because perspective as to the place of guidance in the current scheme of our civilization is the keynote of the book, a psychological specialist may well look in vain for any technical discussion here of the scientific methods and tools involved in the practice of his profession. The book appears to be written essentially by an educator *for educators*, and a highly technical discussion of the guidance process is not the intent of the book.

MARION R. BARTLETT

THE PSYCHOBIOLOGICAL PROGRAM OF THE WAR SHIPPING ADMINISTRATION. *Applied Psychology Monographs, Number 12.*

Edited by Goerge G. Killinger, with a foreword by Captain Edward Macauley, and an introductory chapter by Justin K. Fuller. Published for the American Psychological Association by Stanford University Press, Stanford University; Geoffrey Cumberlege, Oxford University Press, London. $4.00 (cloth); $3.00 (paper). 351 pp. + 19 plates; text ill. 1947.

This monograph describes the psychobiological phases of the responsibilities of the War Shipping Administration during World War II. These responsibilities included an extensive program of selection, training, and maintenance of the large number of personnel operating the greater proportion of merchant vessels during the conflict. It is fortunate that this monograph has been published, since few people even in the field of psychology are aware that this program existed. It has not been as widely known as the similar work in the military services. The program was operated by the USPHS in conjunction with their legal responsibility of caring for the health of the Merchant Marine.

The origin of the activities is presented, along with a general discussion of the purpose and function of the psychobiological aspects of the program. These involved procurement and selection of personnel, with most emphasis placed on the elimination of emotionally unstable individuals. Following selection, cadets were placed in training schools either of an elementary training nature or special schools for upgrading for specific skills or for officer material. One of the large aspects of the work was rehabilitation of mental casualties following the strain of severe operating conditions or battle action. This included rest programs and, where necessary, active therapeutic treatment.

For purposes of selection a Group Personality Inventory and Personal Data Sheet were developed which served as the core of all screening. These are primarily psychiatric inventories employed to eliminate the placement of potential psychotic and psychoneurotic individuals in the crews of vessels subject to war conditions. The authors contend that after several revisions of the inventory they were able to establish a critical score that screened out 66 per cent of the neuropsychiatric subjects while only eliminating 6 per cent of the normal subjects.

Section D of the report, in 6 chapters, presents a sampling of the characteristics of wartime merchant seamen, such as background, color training problems, literacy, etc. The area of Mental Hygiene activities includes educational methods, morale building procedures, training for leadership, and the psychobiology of the purser-pharmacist's mate who was expected to help maintain the psychological health of the men at sea. The evaluation of the entire program is based on a complete record system and follow-up studies of the men who were selected, trained, and assigned to duty by the service. The report presents a thorough use of neuropsychiatric techniques applied to a specialized group of individuals under stress conditions. With careful variation, many of the techniques could be employed with other specialized groups of men needed in large number for such restricted duties.

R. Y. WALKER

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MODERN SEX LIFE. *With Case Histories. Second Edition.*

By Edwin W. Hirsch. Permabooks, New York. 35 cents (paper). xvi + 236 pp. 1949.

This little book is a regrettable addition to the literature on sexuality destined for popular consumption. In his chapter on the Kinsey Report, after glorifying it as having "awakened great national interest" and . . . being "great and monumental," the author says that this "would not have been possible without the pioneer work of Freud. He was the brilliant researcher, proved many of the illnesses of the mind were caused by not living a wholesome sex life." With this doubtful tribute to Freud, he goes on to show that he has only the faintest conception of the psychology of sexuality. An example of a pernicious doctrine to be spread wholesale among laymen is the assertion that during intercourse, if the female partner tends to be frigid, it is the male's obligation to masturbate her by massage at the clitoris. True, the advice is not couched in such bald terms but that is exactly what it amounts to. This will show the extent of the author's ignorance concerning sexuality, and the untold harm that may result from the propagation of such doctrines. There ought to be some way to prevent the wide distribution of such books.

WENDELL MUNCIE

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THE PSYCHOLOGY OF SEX. *Pelican Books A194.*

By Oswald Schwarz. Penguin Books, Harmondsworth, Middlesex. 1s. 6d. (paper). 296 pp. 1949.

This is an excellent small pocket-book on the sexual function as an item in overall personality function, and it is to the author's credit that at no point does he deviate from sexuality in this light. This book can be thoroughly recommended. It is full of wisdom, both for medical persons and the laity, and it is to be as much recommended as the book by Hirsch (reviewed above) is to be condemned. Throughout the book there is an implicit or outright plea for the inclusion of the sexual life under the principle of morality, and while the author's view of morality may not suit certain rigid conceptions of the subject, it will find wide acceptance in medical circles.

WENDELL MUNCIE

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PSYCHOSEXUAL DEVELOPMENT IN HEALTH AND DISEASE. *The Proceedings of the Thirty-Eighth Annual Meeting of the American Psychopathological Association, Held in New York City, June, 1948.*

Edited by Paul H. Hoch and Joseph Zubin. Grune & Stratton, New York. $4.50. x + 283 pp. 1949.

This volume probably contains more meat, more sense, and sheds more scientific enlightenment on the complex problems of psychosexuality than the entire flood of reports, commentaries, case studies, and discussions that appears to have been the mainstay of publishers and printers for the last half-decade. It can be recommended to the readers of this *Quarterly* without reservation and with the single qualification that it is not nearly long enough—a qualification that can hardly be made for most books today.

The volume is a multi-disciplined survey in which the field of sexuality is exposed to the respective attentions of taxonomists, biologists, anthropologists, psychologists, psychiatrists, psychoanalysts, and sociologists. What emerges is a comprehensive and panoramic perspective of the field, literally a topography which, while it exposes more than anything the arid wastes of our knowledge, occasionally reveals the gardens and orchards that have been well-tended. The first paper, in which the basic problem is stated, is by the authors of "The Report," Kinsey et al. While it is somewhat pompous and didactic in tone, it performs its introductory function. Gantt, and then Beach, next expound pertinent biological data. C. S. Ford then informs us of the parallelisms that obtain as to sex mores among 150 cultures apart from our own. At the end of this section, Kardiner objects that what has thus far been presented is dangerously misleading, and he deplores work which compares human sex behavior with animal behavior or draws unwarranted and untenable inferences from practices in primitive societies where the social context in which such behavior takes place is so different from ours.

The anthropologists, Henry, Hallowell, and Mead, command attention to their data in the second section. In the third, R. L. Frank opens the psychoanalytical discussion with an excellent summary of Childhood Sexuality. Rado follows with a "rediscovery of the obvious" and interestingly develops his adaptational view of sexual behavior, which includes a reexamination of the libido theory. Unfortunately, this article suffers from too much condensation, and one wishes Rado had had more time to develop his thought. Bychowski is competent in an article dealing with psychoanalytic experience in the light of the Iowa researchers' findings. In an address, Knight correctly blasts the "strong-arm" methods of therapy with patients who suffer from psychosexual disorders.

In the last section the sociologists, Burgess, Frazier, and Murdock, have their say. Murdock's paper surveys 250 societies. He finds intrafamilial incest taboos universal, premarital license granted among three-quarters of human society, and strikingly states that "our own sexual code is even more of an ethnological curiosity than is cannibalism or the couvade." Discussing this article, Kingsley Davis rejects the interpretations Murdock places on such data.

All considered, the American Psychopathological Association is to be congratulated for having assembled this material. I would, however, rebuke the publishers for not providing the volume with a more provocative title to insure a wider distribution. A book like this could be a much-needed antidote to the trash circulating today under the guise of science.

ROBERT LINDNER

HUMAN BIOLOGY

DAS RELIGIOSE WELTBILD EINER FRÜHEN KULTUR.

By Ad. E. Jensen. August Schroder, Stuttgart. DM 12.50. xii + 199 pp.; ill. 1949.

This recent book of the well known Africanist, Director of the Frobenius Institute in Frankfurt, is rather representative of the orientation of the majority of present day German ethnologists. Their approach is historical, that is to say, they approach a primitive culture primarily in order to understand its place and role in the prehistory of mankind. Jensen agrees in principle that phases of this history can be isolated in the form of "culture areas" or "cultural cycles," but is highly skeptical as to the validity of those "cultural cycles" reconstructed in the past by Frobenius, Graebner, Ankerman, Father Schmidt, and others. After undertaking a criticism of Frobenius, he feels that these reconstructions have so far been based on statistical work with heterogeneous, mostly material elements (studied in museums), and have therefore been condemned to failure in view of the organismic quality of cultures. (This is the "gestalt" approach, entering German ethnology through Frobenius and Krause in the 1920's, U. S. anthropology through Benedict, Opler, and others, in the 1930's.) Jensen bases his reconstruction on mythology as being more likely to reflect central themes (patterns, configurations, the "Weltbild"—world view) of different cultures. He starts with the myth of the killing of the lunar goddess in West Ceram (Indonesia), discovered by himself, and marking the beginning of death *and* procreation among men and the cultivation of plants. Many ceremonials, especially puberty ceremonials, enact this myth. Jensen finds the same myth and ceremonials in such different tribes as the Marind-Anim, Kiwai-Papuans, Khond, Californian Indians, Uitoto, Pangwe, and Southern Rhodesians. He finds clear remnants of it in the Eleusinian mysteries, and other religious productions of high culture. These parallels that cannot be explained by psychology suggest the widespread existence of an early culture, introducing the domestication of plants and creating this particular myth. Jensen calls this "Kulturkreis" tentatively "lunar" and shows his relations to earlier studies of Frazer, and to the "malayo-nigritic" (or "equatorial," etc.) "Kulturkreis." This short summary can by no means do justice to the perspicacity, caution, and insight of Jensen's study. There is an English summary of 8 pages.

ERWIN H. ACKERKNECHT

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IBO VILLAGE AFFAIRS. *Chiefly with reference to the Village of Umueke Agbaja.*

By M. M. Green. Sidgwick and Jackson, London. 10s. 6d. xii + 262 pp. + 1 map. 1947.

In the midst of the kingdoms of West Africa, well known for their high degree of political organization, live nearly four million Ibo-speaking people, crowded together in Southeastern Nigeria to the extent of 300 to 1300 heads per square mile, in a state of complete political atomism. The fact is an unusual challenge to the social scientist, and an unusual headache to colonial administrators. Through prolonged studies in an Ibo village, Mrs. Green has tried to ascertain those elements of social cohesion that permit a normal functioning of Ibo society in such unusual circumstances. Even in the village, which is the only political unit, authority is dispersed among groups rather than centralized in any individual or body. Kinship, religion, and markets are integrating factors. Strict exogamy combined with polygamy tends in the case of the Ibo to establish bonds beyond the village and to mitigate intervillage fighting. Women's organizations, on a village basis as well as that of a common place of descent, play an important role. This most excellent monograph keeps up the high standards for which we envy the British school of cultural anthropology. It is equally attractive because of its new and interesting data and its lucid and intelligent presentation of them.

ERWIN H. ACKERKNECHT

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HORTUS GUARANENSIS. *Generalidades. Segunda Parte.*

By Julio S. Storni. Gabinete de Etnologia Biológica, Universidad Nacional de Tucumán, Tucumán, Argentina. (Paper). 136 pp. 1948.

This is the second of 2 volumes dealing not with plants but with the etymology of the language of the Guaraní. Among other things the first volume (1939) dealt with the toponyms, foods, institutions, etc., while the present one touches upon the physical organism, including its organs and functions, psychical faculties, diseases, etc. The main body of the work is an etymological account of Guaraní with an interpretation of each term including the Spanish equivalents. The author hopes that the study of this work, along with the several companion volumes in this series, may give some idea of the cultural state to which the Guaraní had risen at the time of the Spanish Conquest.

W. H. Hodge

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BIOMETRY

The Science of Chance—*From Probability to Statistics.*

By Horace C. Levinson. Rinehart & Co., New York. $2.00. viii + 348 pp. 1950.

The science of statistics got its start from the questions which professional gamblers put to mathematicians three centuries ago. Levinson follows this historical route in his approach to statistics. The first 13 chapters of his book are concerned with statistical aspects of games of chance—poker, roulette, lotteries, craps, and bridge. The last 6 chapters deal with statistics proper and with their use in a variety of applications, principally business.

The Science of Chance is a revision of the author's earlier book, *Your Chance to Win.* It is not a text on statistics, but rather a book about statistics and the theory of probability. Reading this book will not make anyone a statistician, but it will certainly leave him with a clear notion about the fundamentals of statistics and statistical reasoning. Even if the reader has no interest in statistics as such, he is almost certain to be fascinated by the lucid discussion of luck, gambling, and games of chance. The author's treatment of the subject, incidentally, is almost entirely at the verbal level; formulae and numerical materials have been kept at a minimum.

A. Chapanis

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DE OMNIBUS REBUS ET QUIBUSDAM ALIIS

Author's Guide *for Preparing Manuscript and Handling Proof.*

John Wiley & Sons, New York. $2.00. xv + 80 pp. 1950.

It can be said without fear of contradiction that practically all editors of scientific journals and all publishers will agree when it is stated that a book such as this should be in the library of those who write for publication and, furthermore, should be *regularly* consulted.

David B. Tyler

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Histologische Technik. *Einführung in die Technik der normalen und pathologischen Histologie für Anfänger. Einführung in die medizinische Laboratoriumstechnik in Einzeldarstellungen.*

By Thilde Gröbl. Verlag Wilhelm Maudrich, Wien. $5.40. viii + 201 pp. 1950.

This is the second volume of a 2-volume series edited by Thilde Gröbl and Maria Fischer-Gröbl. The first volume (by the latter author), not reviewed here, is concerned with clinical-chemical methods of medical laboratory technique. The second volume is the usual indispensable handbook for the student or hospital technician, containing introductory chapters on the microscope, microtome, handling of materials, fixation and clearing, followed by specific techniques of staining and preparation. The book does not aim to be encyclopedic, but it is representative and not all elementary. Many of the techniques are of recent origin or modification. Thus the Papanicolaou diagnostic technique for tumor cells is given, as well as a modification of it. Since the text is German, it is unlikely that it will be adopted for class use in this country, but it could be profitably employed as a reference book.

Earl H. Newcomer

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Practical Section Cutting and Staining.

By E. C. Clayden. Chemical Publishing Co., Brooklyn. $2.75. viii + 129 pp. + 3 plates; text ill. 1948.

The author states in the preface of this book that it "is written essentially for technicians with little or no experience in the various methods of preparing routine sections. . . . Covering the basic principles of histological technique, it is hoped that this book will be found valuable for those intending to sit the examinations of the Institute of Medical Laboratory Technology." The author, being Senior Technician in a London hospital, would seem to be well qualified for such a work, and his book testifies to his competence.

The book should find a wider use than that hoped for by the author. Teachers could well use it for a textbook, and practicing technicians will learn from it some new or modified techniques. However, possibly its greatest value for the latter lies in what the author refers to as tips. These are observations as to why a thing won't work, how to do it and why, things to cleave to or eschew, etc., those invaluable tidbits of information which often make the difference between a good or a bad preparation, or technician.

The style is terse, succinct, and authoritative, without being dogmatic or conveying the impression that this is the only way to do it. The book avoids the cook-book air of finality and orthodoxy, especially in the sections devoted to fixation and clearing, by discussing the advantages and disadvantages of the respective techniques. Nothing of microscopy, staining in general, nor theory are included, the bulk of the book consisting of specific techniques for specific purposes. There are some line drawings and a few nice photomicrographs.

EARL H. NEWCOMER

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LABORATORY TECHNIQUE IN BIOLOGY AND MEDICINE. *Second Edition.*
By E. V. Cowdry. The Williams & Wilkins Co., Baltimore. $4.00. vi + 269 pp. 1948.

The first edition of this well prepared, comprehensive manual was published in 1943 under the title *Microscopic Technique in Biology and Medicine* (cf. *Q.R.B.*, 19: 158). The present edition retains the original form and style but has been expanded considerably to include new methods which have come into use as a result of recent advances in physical and microchemical procedures. Many of the standard techniques also have been revised. In its new form it continues to be one of the outstanding manuals of histological technique and should find even wider use than previously.

MARY E. RAWLES

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CE QU'IL FAUT SAVOIR SUR LE MONDE MICROSCOPIQUE. *Méthodes de Récolte, d'Examen et de Préparation; Eléments de Microphotographie.*
By L. J. Laporte. Paul Lechevalier, Paris. 400 fr. (paper). 315 pp. + 24 plates; text ill. 1946.

This is a popular introduction to the varied uses of the microscope, intended for amateur microscopists. It is similar in general scope to the larger French works of Langeron and Séguy, but much less detailed. The text figures are of poor quality, but some of the plates of photomicrographs (diatoms, radiolarians, etc.) are excellent.

M. J. D. WHITE

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LE MICROSCOPE: *Emploi et Applications. Volume II. Encyclopedie Pratique du Naturaliste. XXXIV.*
By E. Séguy. Paul Lechevalier, Paris. 2,000 fr. Pp. 321-1062 + 99 plates; text ill. 1949.

This is the second volume of a general work on microscopical technique, consisting of numbered paragraphs dealing with technical methods of the most diverse kinds. In the present volume there are 1182 such paragraphs devoted to methods for studying particular groups of animals, histology, coprology, botany, geology, metallurgy, photomicrography, microchemistry, etc. The arrangement of these sections does not seem to follow any orderly plan and the work as a whole is an uncritical compilation. Many of the sections are too brief to be of real use to a serious investigator, and a high proportion of the methods are somewhat archaic. The bibliography of 38 pages is perhaps the most useful feature of the book. Following the text is an "atlas" of 200 expensively produced plates, 12 of which are in color. Some of these are of microscopes (Zeiss, Bausch and Lomb, Cooke Troughton and Sims, and other makers); the remainder depict microscopic "objects" of the most varied kinds. The utility of these plates in a work of this nature is not obvious.

M. J. D. WHITE

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OPTICS. *The Technique of Definition. A Focal Press Book.*
By Arthur Cox. Pitman Publishing Corp., New York. $5.75. xii + 412 pp.; ill. 1949.

Biologists have come to rely heavily on photographic methods for recording all manner of data, and know that the lenses involved in such work are the most expensive part of the equipment. So many factors are possible variables in lens design, and the interrelationships among these factors are so complex, that each lens is a compromise planned for definite types of use. The nature of these compromises, and the way in which they affect the manner of employing each lens for maximum definition, is the basic subject of this practical, straightforward book. As such it will be of immense value among scientists. The subtitle Technique of Definition indicates the direction in which Cox's treatment is aimed. He discusses at length the "ideal lens" and its difficulties, the chief lens types, their variants and applications—always with a helpful comment on possible interchangeabilities. Depth of acceptable focus is treated fully. Procedures in testing optical equipment are outlined in enough detail to enable any careful experimenter to learn how far he may expect his lens systems to go in a number of directions. Chapters on Aids to Better Performance and on Accessories add a number of precise physical techniques to the general run of attachments and gadgets on the market, and indicate the benefits to be derived from use of each. A number of excellent tables, an abundance of pertinent line drawings, a glossary, bibliography, and index extend further the reference value of this readable book.

LORUS J. & MARGERY J. MILNE

VOL. 25, NO. 4 December, 1950

THE QUARTERLY REVIEW of BIOLOGY

A CRITIQUE ON THE PHASE THEORY OF LOCUSTS

By K. H. L. KEY

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IN the course of studies on the ecology and epidemiology of the Australian Plague Locust, *Chortoicetes terminifera* (Walk.), extending over a period of some ten years, the author became increasingly convinced that the concepts and terminology of Uvarov's Phase Theory were often so ambiguous and vague as to be prejudicial to clear thinking. It also appeared that the content of the Phase Theory had been gradually extended to cover phenomena which could be more profitably studied and described within a different framework and by a different terminology.

These opinions were reinforced when the author undertook a study (unpublished) of adult phase differences in *Chortoicetes terminifera* and the related *Austroicetes cruciata* (Sauss.), and he was accordingly led to make a critical reexamination of the Phase Theory on the basis of all the available literature. It is the purpose of this paper to record the results of that review.

In order to present in a readily accessible form the major part of the relevant factual material, it has been thought advisable to give a somewhat lengthy account of the history of the development of the Phase Theory from its first publication up to 1947, at which time the manuscript of this paper was completed. This course seems all the more necessary since many of the aspects to which special reference will need to be made are given little prominence in existing accounts of the Phase Theory. The history is followed by a detailed discussion of the basic concepts and terminology, and by the conclusions to which the analysis as a whole has led. Of papers published since 1947, those available to the author do not call for any revision of these conclusions.

To avoid confusion between references to page numbers in other publications on the one hand, and cross references within the present paper on the other, round brackets have been consistently used for the former, and square brackets for the latter.

HISTORICAL DEVELOPMENT OF THE PHASE THEORY

The Period up to 1928

The Phase Theory was first propounded by Uvarov (1921), following the failure of his attempt to provide a basis for the rigid taxonomic separation of the supposed species *Locusta migratoria* L., *L. danica* L., and *L. migratorioides* R. & F. Although the theory was presented in outline only, and some of the ideas comprising it are now known to have been fallacious, nevertheless this first statement of the theory is important as indicating the class of phenomenon which its originator intended it to cover. The theory was intended to explain "the problem of the inter-relations of *migratoria*, *danica* and *migratorioides*" (p. 153), which could not be separated specifically, and represented "taxonomic units of lower grade than the species" (p. 153), connected by transitional forms. The names of various infraspecific categories were reviewed, and finally the term "phase" was chosen as the most appropriate by which to designate the forms under consideration. The phases were designated by the old specific names prefixed by "ph.", or simply as the "gregarious phase" (or "swarming phase") and the "solitary phase."

In their typical development the phases were distinguished on the now well-known morphological and color characters of adults and nymphs, and on the degree of sexual dimorphism in size. With these physical differences are correlated biological differences, of which the chief are the gregarious and migratory behavior of *migratoria* and *migratorioides*, as against the non-gregarious, sedentary behavior of *danica*. A supposed difference in embryonic development has not been confirmed by subsequent observations. Phase *migratoria*, and probably phase *migratorioides*, has characteristic and restricted "permanent breeding grounds," whereas *danica* is much more generally distributed.

Field observations by Uvarov, and laboratory experiments of Plotnikov, convinced Uvarov that in succeeding generations ph. *migratoria* can be transformed into ph. *danica*, and vice versa; that is, the progeny of typical *migratoria* can be *danica*, and the progeny of typical *danica* can be *migratoria*. Phase *migratorioides* was regarded as a further modification of *migratoria* in the direction opposite to *danica*. The conditions responsible for the transformation were at this stage unknown, but it was suggested that transformation from the solitary to the gregarious phase was much favored, and probably caused, by oviposition of the solitary phase under conditions like those of the permanent breeding grounds of the gregarious phase. When this takes place, the multiplication and eventual emigration of the locusts are favored, for "the gregariousness of the *migratorioides* phase is, of course, one of the causes of a rapid increase in the number of individuals and swarms . . ." (p. 154). No grounds were given for the statement just quoted. After emigration, "the number of locusts in the breeding grounds drops suddenly to a minimum, and scattered swarms of the gregarious phase, as well as the progeny of individuals of the solitary phase, cause the gradual increase in the number of swarming individuals, and after a few years a new emigration occurs" (p. 155). From this it is concluded that "the periodicity of locust invasions is caused entirely by the wonderful phenomenon of the transformation of a swarming locust into a solitary, harmless grasshopper" (p. 155).

Observations of J. C. Faure, which Uvarov quoted, showed that two forms, quite analogous to the phases of *Locusta migratoria*, exist in *Locustana pardalina* (Walk.). These differ in their morphology, color, and behavior, and the observations indicated that the solitary phase (ph. *solitaria*) can transform, in succeeding generations, into the gregarious phase (ph. *pardalina*). According to Uvarov, this gave "very strong support to the theory of phases as a direct cause of the periodicity" (p. 159).

In this early stage of its development, the Phase Theory is reducible to three basic propositions:

1. In each of the locusts *Locusta migratoria* and *Locustana pardalina* there are two distinct forms of infraspecific status—the "phases"—which are connected by transitional forms, and are mutually transformable in successive generations.
2. The transformation from the "solitary phase" to the "gregarious phase" takes place most readily in the restricted "permanent breeding grounds" of the gregarious phase.
3. The transformation of the phases is responsible for the periodicity of locust invasions, because the gregarious phase is capable of more rapid multiplication than the solitary phase, and is migratory, whereas the solitary phase is sedentary.

It should be noted that the phases were defined on characters of structure and color, just like any other taxonomic unit, although it was pointed out that, as in the case of subspecies, there were intermediate forms that could not be assigned to either phase. The biological characters of gregariousness, etc., were clearly supposed to be closely linked with the physical characters, so that the former could be inferred from the latter, just as the biological characteristics of a sufficiently studied species can be listed when the species has been determined on diagnostic physical characters. On no other assumption would it be possible to ascribe the periodicity of locust invasions to the transformation of phases, when phases are defined on physical characters. However, it is implied that, to merit the appellation "phase," an infraspecific category must possess the distinctive relation to the opposed but mutually transformable states of migratory gregariousness and sedentary isolation, respectively.

In his second paper dealing with phases, Uvarov (1923) suggested that the forms previously recognized as *Acridium flaviventre* Burm. and *Acridium coangustatum* Lucas represent the respective solitary phases of the species *Schistocerca gregaria* Forsk. and *Nomadacris septemfasciata* Serv., since they were always found singly, and bore much the same morphological relation to the forms of these species found in swarms as the solitary phase bore to the gregarious phase in *Locusta* and *Locustana*. These suggestions have been confirmed by Johnston (1926) and others, and observations on other species of locust by numerous authors have demonstrated in all of them the same polymorphism, bearing the same relation to gregariousness and migration.

Faure (1923) showed, by cage experiments on *Locustana pardalina*, that the cause of phase transformation, about which Uvarov had been uncertain, is the degree of crowding of the nymphs. That is, nymphs with the coloration of the gregarious phase (Faure used the term "swarm phase") develop the coloration of the solitary phase, after one or more moults, if they are separated from their fellows and maintained in isolation or near-isolation; and solitary phase nymphs develop the coloration of the gregarious phase if a large number are confined in one cage. This conclusion was fully substantiated by more detailed experiments (Faure, 1932), on the same species, and on *Locusta migratoria* and *Schistocerca gregaria*, and has been confirmed by many other authors for the same and other species. It permitted a clearer definition of the process of transformation in the field, which consisted (Faure, 1923) in a multiplication of the solitary phase in the "natural breeding grounds" of the locust, and the gathering of the insects into loose swarms, in which the transformation of color, and thus of phase, took place as in the cage experiments. Faure adopted essentially the same attitude as Uvarov with regard to the connection between phase transformation and the periodicity of outbreaks. He stated (1923, p. 21): "As Dr. Uvarov has well pointed out, the insect succeeds in maintaining itself during the years when no swarms occur, by living as a solitary grasshopper. As far as our brown locust is concerned, this explanation of its periodic abundance is no longer a theory but an established fact."

In the same paper of 1923, Faure called attention to the fact that the progeny of the gregarious phase can be distinguished from that of the solitary phase immediately on hatching by its black color, which had thus been "inherited" from its parents.

In his book *Locusts and Grasshoppers*, Uvarov (1928) summarized the findings of himself and others with regard to phases in locusts, and discussed various criticisms of the Phase Theory that had meanwhile been published. At the same time he offered certain new suggestions with regard to the mechanism of phase transformation and its relation to the periodicity of outbreaks. In this publication we find the first hint of an inconsistency with regard to the definition of phases which has since become much more serious and confusing. Thus on p. 147, and again on p. 159, the conception of phases was introduced in the same way as in previous papers, emphasis being placed primarily on structural and color differences, with which the biological differences were assumed to be correlated. But on p. 167 we find the statement "... it must never be forgotten that the main and principal difference between the phases lies in their bionomics, while their morphology is only the apparent result of some deep physiological differences."

Starting from the observations of Faure (1923) and Plotnikov (1927) that phase transformation depends upon population density, and with the general observation of much greater locomotor activity in the gregarious phase, Uvarov suggested that the prominence of black pigment in the hoppers of the gregarious phase should be ascribed to the accumulation of certain metabolites as a result of the high activity. Further, the black cuticular pigment would increase the body temperature of such hoppers and thus lead to still greater activity, so that a "vicious circle" would be formed, and "the species involved in it must progress in the direction of further development of the swarming phase" (p. 161). Also, because the gregarious phase appears as a consequence of crowding, and gregariousness implies the maintenance of crowding, "this process can only increase in intensity, and not decrease, no matter what the other conditions are . . . " (p. 161). Transformation into the gregarious phase leads to emigration. Since "as a rule only such years of migration and of the appearance of swarms in unusual regions are recorded as the years of appearance of locusts, and they serve to calculate the periodicity" (p. 161), it therefore followed that phase transformation was responsible for the periodicity. However, there are several indications in the book that Uvarov also believed that transformation into the gregarious phase results in an increase in reproductive potential, and thus in an accelerated increase in the *general* population level, not merely a local increase in population resulting from migration. This would be in agreement with the views already quoted from his 1921 paper, and may be illustrated by the statement (1928, p. 248): "An increase in numbers is followed by the appearance of the swarming phase, and the curve [of numbers] starts to rise suddenly. Then an emigration follows. . . ". In a later contribution on the subject (Uvarov, 1937, p. 11), this point of view was abandoned.

Uvarov's book proved a tremendous stimulus to locust research all over the world, and an increasing number of papers on phases was published every year, reaching a maximum between 1934 and 1939. These studies resulted in much elaboration of detail, but contributed few really fundamental ideas to the Phase Theory, which may be said to have reached maturity with the publication of Uvarov's book. It will be convenient to study this later history under the following three heads, representing natural divisions of the accepted field of the theory:

1. the characterization and differentiation of the phases;
2. the mechanism of phase transformation in the field and the laboratory; and
3. the relation of the phases to the development of outbreaks and their periodicity.

Characterization and Differentiation of the Phases

In a general discussion of locust phases and their interrelations, Uvarov and Zolotarevsky (1929) moved still further from the original mainly morphological conception of phases. They stated (p. 261): "Biological differences are, of course, of primary importance, but the conception of phases in the minds of most workers remains mainly morphological, and they are trying to find absolute characters in the structure and color that would enable one to refer each specimen to a definite phase." They referred to the phase of a species as its "biological status," and elsewhere spoke of "biological phases" (p. 263). Also: "it would be futile to attempt to identify phases of locusts on the bases of the morphological and color characters of the specimens" (p. 264). However, these strictures are not directed so much against the use of physical criteria in separating the phases, as against their use in species or subspecies for which the physical characteristics of swarming and non-swarming material have not yet been properly established.

In accordance with their trend away from the taxonomic aspect of phases, Uvarov and Zolotarevsky proposed the use of the now widely accepted general terms, *solitaria*, *gregaria*, and *transiens*, to be applied to the phases of all locusts without regard for nomenclatural priority. Although these terms were not regarded as taxonomic in the ordinary sense, they were latinized and printed in italics. "*Phasis solitaria*" was to be applied to "the extreme form" represented by isolated individuals that could have had no immediate swarming antecedents, and "*phasis gregaria*" to "the extreme form found in dense, large, emigrating swarms." "*Phasis transiens*" would cover all the intermediate forms occurring "when the species is on the increase and its individuals are beginning to form loose aggregations, or on the decrease, and the swarms are becoming loose and tend to scatter . . ." (p. 262). It was subdivided into ph. *congregans* and ph. *dissocians*, terms that could be used in place of *transiens* when the direction of change of the phase of the material was known. Uvarov's original ph. *migratorioides* became the ph. *gregaria* of a distinct subspecies *migratorioides* R. & F. within *Locusta migratoria*, of which other subspecies were also recognized.

Zolotarevsky (1929), in a study of the phases of *Locusta migratoria migratorioides* and *L. migratoria capito* Sauss., determined the length of the tegmen, and the values for the ratios of length of tegmen to length of hind femur (E/F), width of pronotum at the point of greatest constriction to greatest breadth of head (M/C), and height of pronotum to greatest breadth of head (H/C), for a number of series of locusts classified as *gregaria* and *solitaria* respectively, and on the basis of these measurements he characterized the two phases by mean values for the ratios, and by ranges of the absolute values for tegmen length. It is not clear upon what basis the initial classification into *gregaria* and *solitaria* was made. Uvarov (1921) had classified his *migratoria* and *danica* material on physical characters, so that the mean values of his two ratios for "all *danica*" and "all *migratoria*" could only be regarded as giving quantitative precision to this classification without changing the basis of it. Zolotarevsky, however, especially in view of the emphatic statements of Uvarov and Zolotarevsky (1929), probably classified his material in the first instance according to whether it came from swarms or from non-swarming populations without immediate swarming antecedents. In that case, his tables represent a genuine correlation between the degree of gregariousness and physical characters. The phase *gregaria* was found to have an E/F ratio always greater than 2.0. Phases *solitaria* and *transiens* were not separated morphometrically. Zolotarevsky also introduced a method for distinguishing the phases *congregans* and *dissocians* on their physical characters, which he elaborated in subsequent papers.

N. B. The symbols used in the present paper for various bodily dimensions are those recommended by the Third International Locust Conference in 1934, and do not necessarily correspond with those used by the authors whose work is discussed.

Faure (1932) showed very clearly that he regarded the phases as the morphological and color *forms* appropriate to locusts living in swarms and in isolation respectively. Thus he stated (p. 299): "the phase *solitaria* is the *form* [italics mine] living in isolation . . . and the *type* [italics mine] found in large swarms is called the phase *gregaria*." Again (p. 302), ". . . attempts were made to produce the phase *gregaria* out of *solitaria* in three different ways. . . . The results of these experiments may be judged by two different standards: the coloration of the hoppers, and the biometrical measurements of the adults." These are only isolated quotations, but the same point of view pervades the whole paper, as well as all subsequent publications of Faure (1933, 1935, 1943a, etc.). In view of this emphasis on structure and color in the definition of the phases, it is of interest to note that Uvarov (1937) was able to say of Faure's experiments that they had "established the existence of phases as a definite fact" (p. 1). As standards of comparison in determining the effect of his experiments on the adult phase characters, Faure used morphometric data from two main sources, namely, isolated individuals taken at widely separated localities over a long series of years, and specimens "of the extreme swarming phase" from a number of swarms from different outbreaks. Unfortunately, selection was made among the material from swarms on the basis of morphology. Thus material from "swarms of adults that were encountered during the last four or five years" was not used, because these swarms "all consisted of insects of the *transiens type* [italics mine]" (p. 312). Because of this double criterion used in classifying his basic material, the mean values obtained for the two groups cannot be regarded as giving a pure correlation between degree of gregariousness and physical characters, but represent, to some extent at any rate, merely a more precise, numerical statement of the original basis of classification.

It will be noted that Faure's basic standards do not show the range of variation that can be expected to exist between the means of different series of isolated specimens, and between the means of series from different strongly migrating swarms. All the data are lumped into the two categories, yielding means which are attributed to "extreme *solitaria*" and "extreme *gregaria*" respectively, whereas actually they can only represent "average *solitaria*" and "average *gregaria*." The failure to give any indication of range made it impossible for Faure, and later for du Plessis (1939), to state whether any given series of locusts, either collected in the field or bred in the laboratory, had actually reached a condition that could be called *solitaria* or *gregaria*, and Faure had to content himself with such expressions as "varying strongly towards *gregaria*," etc.

Faure's work demonstrated the great importance of absolute size, of which tegmen length was used as an index, as a phase character in *Locustana pardalina*, and the fact that the ratio E/F was less useful than any of the others in distinguishing the phases of this species. It showed also that indications given by the color of the hoppers and the morphometric characters of the adults were not very closely correlated. Thus the hoppers of one series of *Locustana* were recorded as 99 per cent *gregaria*, whereas the adults produced from them were only about half way from *solitaria* to *gregaria* on the criteria of tegmen length and E/F.

In a further study of phases in *Locusta migratoria capito*, Zolotarevsky (1933) introduced the new ratio: length of pronotum/greatest width of head (P/C). He adopted E/F as the main criterion in classifying his material with regard to phase, and regarded the other ratios as providing supplementary evidence. However, the variation of the pronotal ratios was not closely correlated with the variation of E/F. Zolotarevsky was able to show that locusts submitted to low humidity during their development have a higher E/F ratio than those reared at continuously high humidity, although the difference is not nearly as great as that between the phases. The pronotal ratios are not affected unless the period of dryness is prolonged. Further, brown individuals reared under humid conditions have a higher E/F than green individuals, although there is no difference in the pronotal ratios. Brown individuals submitted to prolonged dryness show a greater lowering of the pronotal ratios than green individuals similarly treated. These observations are important as showing that the chief distinguishing characters of the phases are subject to modification by factors other than population density. Similar observations were subsequently made by a number of other authors. This immediately introduced complications in the characterization of the phases. Zolotarevsky proposed to regard as "typical" *solitaria* only such locusts as had certainly developed in isolation, and had not been subjected to prolonged dryness. Such individuals showed a mean value for E/F considerably lower than the value previously adopted for phase *solitaria* (Zolotarevsky, 1929). Nevertheless (p. 130), locusts in which E/F had been elevated by dry conditions into the range characteristic of ph. *congregans* should still be regarded as *solitaria* (presumably not "typical") if they had certainly developed in isolation, "d'autant plus que la conception de la phase *congregans* comporte la condition de l'accumulation des larves, aboutissant ou non au comportement grégaire."

At the Third International Locust Conference held in London in 1934, methods of calculating average morphometric ratios for series of specimens, in connection with phase studies, were discussed, and the following resolution was carried (see Conference Proceedings, Resolution 3(e)3): "The true average ratio is obtained by calculating the ratio of the totals of the actual measurements and not the average of the individual ratios." This statement has been quoted with approbation by several subsequent authors (e.g., Lean, 1936; Jannone, 1938), sometimes with reference to the Conference resolution as their authority, and sometimes without. Other authors (e.g., Rubtzov, 1935; du Plessis, 1939; Lea, 1938) have tacitly disregarded it, and used the average of the individual ratios. To my knowledge it has never been openly challenged. It was repeated unchanged as Resolution 4 (b) of the Fourth International Locust Conference, Cairo, 1936. The validity of the statement will be examined in a later section of this paper [p. 390].

Michelmore and Allan (1934), in a study of the phases of *Nomadacris septemfasciata*, classified their adult series into *gregaria* and *transiens* according to its degree and history of gregariousness, and based all their series means upon individual ratios. This permitted the calculation of the standard errors of the means, from which the significance of differences between series could be determined. In this respect the procedure of these authors was the most satisfactory since Gause's (1928) statistical analysis of the data on *Locusta migratoria* collected by Uvarov (1921), Plotnikov (1927), and Makalovskaja (1925). However, Michelmore and Allan did not attempt to characterize the two phases by either ranges or means for any of the measures they employed. They pointed out some remarkable color variations in the adults, which were to be ascribed partly to phase differences and partly to ageing, and recalled the earlier observations of Johnston (1926) on color changes in adult *Schistocerca gregaria.* In the latter species young adults produced from swarming hoppers are pink, while those produced from non-swarming hoppers are gray.

Johnston (1934), without quoting supporting data, gave the following E/F ratios for *Locusta migratoria migratorioides*: ph. *solitaria*, 1.70–1.80; ph. *transiens*, 1.80–1.90. Presumably ratios above 1.90 were regarded as *gregaria.* This was the first attempt to give limiting ranges for all three phases of any locust.

Pasquier (1934), in a paper on *Dociostaurus maroccanus* Thnb., introduced the new measure, width of mesosternum (S), and showed that the ratio E/S provides a wider contrast between material from swarms and non-swarming populations than any other ratio.

Rubtzov (1935), in a paper entitled "Phase Variation in Non-swarming Grasshoppers," was the first author to extend the concepts of the Phase Theory to insects other than the gregarious locusts. However, although he referred to the species studied as "non-swarming" and "non-gregarious," he stated that *Aeropus sibiricus* L. "has been occasionally observed to fly in swarms" (p. 500), and that all of six species in which phase variation is quite noticeable (including *Chorthippus albomarginatus* de Geer, on which most of his observations were made) "may occur in bands" (p. 500). It is possible that he was not using the term "band" in the accepted sense, and meant only a dense patch of the insects in which true gregariousness was not exhibited.

Rubtzov noted that in *Chorthippus albomarginatus* considerably more black pigment is present in hoppers and adults from dense populations than in those from sparse populations, and that in rearing experiments the amount of black pigment could be varied by varying the density of the hoppers in the cages. He termed the darkest individuals "*gregaria*," the palest "*solitaria*," and intermediate types "*transiens*." This is an extreme example of the "physical" approach to phase differentiation, and a clear departure from previous practice, in which the phase *gregaria* was always taken to be the form occurring in dense, gregarious swarms, even if it was subsequently defined on morphological and color characters and recognized by these. There is no reference to gregariousness or swarming in any of the material analyzed by Rubtzov. Moreover he states (p. 512): ". . . in the field in the extremely dense populations . . . not more than 70–80% of the individuals can be classified as ph. *gregaria*." It is clear that Rubtzov's "phase *gregaria*" was applied to insects which might be regarded as ph. *transiens* under the accepted terminology, but certainly not as ph. *gregaria*.

In determining what morphometric characters were to be associated with his phases, Rubtzov made a phase classification of mixed adult material on the basis of coloration, and computed means for E, F, and E/F for the resulting groups. Phase "*gregaria*" was found to be larger than phase "*solitaria*," with a higher E/F ratio. Rubtzov admitted (p. 515) that this procedure is "not quite correct," inasmuch as it only establishes a correlation between the color classification and structure. Afterwards, more or less by way of confirmation, mean measurements and ratios were calculated for adult material from dense and sparse field populations, and it was shown that the former had the higher values. In the morphometric work the mean of the individual ratios was used, permitting the calculation of the standard error of the mean, and the determination of the significance of differences between groups.

Chopard (1935) demonstrated the existence of phase variation in an entirely different family of Orthoptera, namely in the Tettigoniidae. In *Barbitistes fischeri* Yersin and *Orphania denticauda* Charp. abnormally dense adult populations have occurred from time to time in France, and in these populations very dark forms are common. It has not been stated whether the insects show actual gregariousness, but they are more active than those of sparse populations. In the case of *Barbitistes*, the dark form had been described as *B. berenguieri* Valéry-Mayet. Chopard contented himself with concluding that these forms were an example of phase variation analogous to that in locusts, and did not attempt to apply the phase terminology.

Lean (1936) explored methods of separating the phases of *Locusta*, especially *congregans* and *dissocians*, on morphological and color characters, and gave rough ranges and means for *solitaria*, *gregaria*, and *congregans*. He attempted to use a "phase graph," in which tegmen length was plotted against femur length for equal ranges of E/F, as the basis of a separation between the phases *dissocians* and *congregans*. Although his conclusions could not be confirmed by later workers (cf. du Plessis, 1939; Kennedy, 1939), the curves themselves show a number of points of interest. Thus, within the males of any one series of locusts, taken at one time and place and of uniform origin, those individuals with the highest E/F ratio show a reduction in the absolute value of F, and may even show a reduction in E; whereas, if we compare males of different series, those series with the highest mean E/F have the *highest* mean values for E and usually for F.

In a study of *Locusta migratoria manilensis* Meyen, Uvarov (1936) presented morphometric data for a number of series from different localities, which he assigned to one or other of the phases. By averaging the data for these series under the headings of *gregaria*, *transiens*, and *solitaria*, he obtained mean values for each phase, which he then used in a comparison of *manilensis* with the other subspecies of *L. migratoria*. Unfortunately, in most of the series assigned to one or other phase, no indication is given as to whether the material was derived from swarms or from a non-swarming population, and several statements show clearly that the structure of the insects had been used as the main criterion in classifying them. Thus we have the statement (p. 102): "Some specimens of the ph. *transiens* from Annam have been received . . . but without any definite data as to their origin." In Malaya "a small incipient outbreak occurred . . . in 1930 . . ."; the adults "*proved to be* [italics mine] of the ph. *transiens*. . . ." (p. 101).

Even cage-bred material has been classed as "ph. *transiens*." All these series have been included in Uvarov's table (p. 93), so that the morphometric characters of the phases of this subspecies are derived largely from material classified on the very basis which the table itself is supposed to establish for the first time. This procedure is in conflict with the recommendations made jointly by Uvarov and Zolotarevsky (1929) with regard to the importance of establishing the biological status of material of each subspecies before any attempt is made at a morphometric characterization of its phases.

Similar objections apply to certain statements made by Uvarov and Hamilton (1936) with regard to morphometric characters in an Algerian race of *Locusta migratoria*. They stated, for example, (p. 87): "... in the F_7 most of the ratios approached very closely those typical of the ph. *gregaria*." Since the Algerian race is not known to swarm, and its subspecific position could not be established even after the work here described, it is difficult to see on what basis the above statement could be made. [This race was subsequently referred to *L. migratoria cinerascens* F., by Capra (1946).]

Husain and Mathur (1936b) showed that the typical color pattern of the phase *gregaria* can be produced in isolated hoppers of *Schistocerca gregaria* by an excess of CO_2 in the atmosphere of the breeding cage; but such individuals, upon becoming adult, show the morphometric ratios characteristic of the phase *solitaria*. In a second paper (1936a), the same authors characterized the types of hoppers produced under different experimental conditions of isolation or crowding as "green type," "intermediate type," or "black type," and thus avoided committing themselves to all the implications involved in the use of the phase terminology.

Butler and Innes (1936) showed that in *Locusta migratoria* the basal metabolism of phase *gregaria* is almost double that of phase *solitaria*. Strelnikov (1936), working on the same species, showed that ph. *gregaria* has a lower specific gravity than ph. *solitaria*, partly because of its lower water content, and partly because of the greater development of air sacs in the tracheal system.

Key (1936), in a theoretical discussion of activity in crowded and isolated locusts, suggested that the most significant difference between the phases was in nervous excitability, or irritability. This concept was confirmed and extended by Kennedy (1939) and Volkonsky (1942).

At the Fourth International Locust Conference, held in Cairo in 1936, two resolutions were passed which are of interest from the point of view of this discussion (see Conference Proceedings, 1937). Resolution 2 (1) reads as follows: "It has now been established by scientific research that a number of species both of locusts and of grasshoppers occur in two phases each of which is capable of transforming itself into the other. The first of these which is relatively harmless, is the solitary phase (*ph. solitaria*), the second, which is dangerous, is the gregarious phase (*ph. gregaria*)." This resolution implies endorsement of Rubtzov's use of the term "phase *gregaria*" with reference to the dark, long-winged forms found in dense populations of (non-swarming) grasshoppers—notwithstanding that the currently accepted definitions of "phase *gregaria*" (Uvarov and Zolotarevsky, 1929) and of "grasshopper" (Uvarov, 1928, p. vii) were not compatible with such use.

The second resolution of interest is Resolution 8, of which section (1) reads as follows: "It has long been known that scattered individuals of different locust species referable to the gregarious phase by reason of their structural characters, have been repeatedly found in the absence of swarms." The implication of this resolution is that, once the structural characters *typical* of individuals of a given species from dense migrating swarms are known, then the phase *gregaria* is defined in terms of those characters, and individuals possessing them are identified as ph. *gregaria* even in the complete absence of swarms. It is not clear whether the meaning of the resolution was intended to include the possibility that these scattered *gregaria* had never at any time been members of a swarm, but the remarks of Johnston (1937, pp. 2–3) certainly carry this suggestion. He reported the occurrence, in several different species and on several different occasions, of scattered individuals of ph. *gregaria* in places where no swarms had been recorded. This suggested that factors other than crowding may lead to the production of ph. *gregaria*. The tendency of later work has been to interpret such observations as indicating individual migrations by locusts that had developed in swarms elsewhere (cf. Waloff, 1940; Brédo, 1945). Even on this basis, it is clear that gregariousness can no longer be accepted as an invariable character of ph. *gregaria*, nor can long-distance migration be regarded as inevitably dependent on gregariousness.

The first suggestions of long-distance migration by solitary locusts had come from Zolotarevsky, de Lépiney, and Dupont (1934), and Rao (1935). Further evidence, for both *Schistocerca gregaria* and *Locusta migratoria*, was provided by Rao (1937, 1938a). At first it was not clear from the accounts whether these "solitary" locusts possess the morphometric characters of phase *solitaria*, but this was placed beyond doubt by Rao and Bhatia (1939), Waloff (1940), Rao (1942), and Volkonsky (1942).

In a discussion of the cycle of events leading to outbreaks of *Locustana pardalina*, Faure (1937) stated (p. 804): "If the population is dense enough, compact swarms may be formed, and the transition into swarms may be said to be complete, although a critical study of the phase characters of the locusts would show that the swarms are composed of a mixture of *solitaria*, *gregaria* and *transitional* forms." Thus, not only can phase *gregaria* behave in a non-gregarious manner, but dense swarms can contain numerous individuals of phase *solitaria*. Subsequent observations by Kennedy (1939) showed that the mean morphometric ratios of a migrating swarm produced early in an outbreak cycle of *Schistocerca gregaria* were lower than the ratios of "extreme *solitaria*" studied by him, and similar (unpublished) observations have been made by the author on *Chortoicetes terminifera* (Walk.).

Rao (1937) suggested a characterization of all three phases of *Schistocerca gregaria* by ranges for E/F, *solitaria* having values of 2.05 and below, *transiens* 2.06–2.15, and *gregaria* 2.16 and above.

Zolotarevsky and Murat (1938) showed that in *Schistocerca gregaria* isolated specimens from the dry interior of Mauritania had a higher E/F ratio, and lower sexual dimorphism, than specimens from the moister coastal districts, i.e., they varied more towards the ratios typical of *transiens*. All these specimens were from sparse populations with no immediate swarming antecedents, and the observations confirmed those made earlier by Zolotarevsky (1933) on *Locusta migratoria capito*; they were repeated by Murat (1939). The females were more sensitive in their morphometric reactions to such climatic differences than the males.

Volkonsky (1938) crowded sexually immature adults of the phase *solitaria* of *Schistocerca gregaria*, and found that they developed the yellow coloration typical of phase *gregaria* as they matured. Of their progeny, 70 per cent were black, i.e., phase *gregaria*. Volkonsky regarded this as a change of phase in the adult stage, although the structural characters were of course unaltered, and characteristic of *solitaria*.

Lea (1938), working on *Nomadacris septemfasciata*, observed that individual (healthy) locusts are liable to drop out of swarms over areas of grassland. Such locusts, now isolated, very rapidly acquire the coloration and the shy, sedentary behavior typical of the phase *solitaria*, while retaining the high E/F ratio characteristic of *gregaria*. Instead of describing this as a change of phase, as Volkonsky (1938) had done in analogous circumstances, Lea introduced the term "solitary-living" to describe locusts of either phase that exhibit the coloration and habits typical of that mode of life. He also found that solitary-living locusts may be taken up by passing swarms, in which case coloration and behavior are rapidly transformed into those characteristic of swarming locusts. Moreover, adult solitary-living locusts "... may, at any time, congregate, and ... this congregation is not confined to locusts of any particular morphological constitution" (p. 15). Thus the general behavior of adults is largely independent of their morphometric characters. In his morphometric comparisons Lea used the means of individual ratios.

Zolotarevsky (1938b) found that solitary-living adults of *Locusta migratoria migratorioides* of the ph. *gregaria* behaved in the same way as ph. *solitaria* in their response to microclimate, but also undertook more extensive movements in response to humidity differences at a distance of several kilometres. In an examination of morphometric and color differences between adults of the phases *congregans* and *dissocians*, he classified his material in the first place on the degree of gregariousness of the *hoppers from which the adults were produced*, and on whether the gregariousness was increasing or decreasing. Frequency distribution curves for E/F for such "*transiens*" series showed two peaks, one at the mean value for ph. *solitaria*, the other at the mean for ph. *gregaria*. The lowest numbers occurred in the intermediate E/F categories in the vicinity of 1.95–1.99. It is also suggested that after transformation from ph. *solitaria* has reached a certain point, it proceeds rapidly over to typical *gregaria*. It may be noticed that the phase categories are being used here in two conflicting senses. First a *series* (population) was called "phase *transiens*" on the basis of hopper behavior, and then, when this series was analyzed morphometrically, it appeared that the majority of the insects were either phase *solitaria* or phase *gregaria*, relatively few being *transiens* in structure. When mean values for E/F were calculated for males and females separately in three series classed respectively as "*solitaria*," "*congregans*," and "*dissocians*," using only insects with E/F less than 2, the values for the males were found to be lower than those for the females in "*solitaria*" and "*congregans*," but higher in "*dissocians*." Since most reliable observations on *L. migratoria* have shown E/F to be lower for males than for females in *solitaria*, *gregaria*, and *congregans*, the reversal of this relationship in *dissocians* could be explained by assuming a more rapid transformation of females than of males in both directions, an assumption supported from other sources (cf. Zolotarevsky and Murat, 1938; du Plessis, 1939). A similar comparison of the sexes in the three groups, this time with reference to M/C, and to P/C calculated for different categories of E/F, led to similar conclusions, namely that "*dissocians*" can be separated from "*solitaria*" and "*congregans*" by making use of the different rates at which these ratios change in response to changes in the degree of gregariousness of the hoppers, and the different rates at which a given ratio changes in males and in females.

It should be noted that the statistical significance of most of the differences reported in this study is extremely doubtful. Moreover the suggestion that phase transformation of females is more rapid than that of males is in conflict with the fact that in the "*congregans*" series a much higher percentage of the males than of the females has a ratio greater than 2, i.e., has passed completely over into the phase *gregaria*.

Pasquier (1938) showed that there is a variation in size in *Dociostaurus maroccanus* and *Calliptamus italicus* L. in association with different habitats and seasons; he called this "ecological variation." In *C. italicus* the E/F ratio increases with increase in size, and to such an extent that false conclusions could be drawn regarding phase transformation. Pasquier suggested that the differences observed in the degree of expression of the characters of "extreme *gregaria*" of *D. maroccanus* from different outbreak areas may also be explained as ecological variation.

Jannone (1938), in a detailed study of the phases of *Dociostaurus maroccanus*, defined these purely on the basis of state of gregariousness, and proceeded to examine the physical characteristics of the resulting groups. The morphometric characters most useful as phase indicators were the absolute measurements, especially the total length of the body and the length of the tegmen, and the E/F ratio. All the absolute measurements were considerably greater in phase *gregaria* than in phase *solitaria*, especially in the male, and there was no overlapping between the ranges of individual values for the total length of the body or the length of the tegmen, in the two phases. Tentative ranges were given for series means of E/F in *solitaria* and *gregaria*, and here again there was no overlapping. The ratios P/C, H/C, and M/C were found to show little or no correlation with phase. Although Jannone measured as many as 1271 specimens, full use cannot be made of his work because of the impossibility of applying statistical criteria to his ratios, which were calculated from the totals of the absolute measurements. A study of color differences between the phases led to the conclusion that the color pattern, including the amount of black pigment, is not a pronounced phase character, even in the hoppers, but ph. *gregaria* adults show a diminished pattern contrast. Jannone confirmed and extended the observations of Paoli (1937) with regard to the higher fecundity of ph. *gregaria* in *D. maroccanus*. Females of this phase laid some 50 per cent more eggs per pod than phase *solitaria*; the number of ovarioles in the ovaries was the same in the two phases, but more eggs matured at one time in ph. *gregaria*.

Rao (1938b) extended observations made earlier by Roonwal (1936) on a new phase character in *Schistocerca gregaria*. He found that in ph. *gregaria* there were almost invariably 6 eye-stripes and 26 antennal segments, while in ph. *solitaria* there were 6 or 7 eye-stripes and 28 or 29 antennal segments.

Du Plessis (1939) carried out a most discriminating study of the adult phase differences in *Locustana pardalina*. His general viewpoint, although not stated explicitly, appears to have been that the phase of a given population is defined by its degree of gregariousness, and that the morphological characters of the adults are "an *expression* [italics mine] of phase" (p. 25). Thus the first object of the study was stated to be to ascertain "the amount of [morphological] variation in different phase groups of adults of known origin, and its significance; and the best *indications* [italics added of phase, as revealed by this variation" (p. 25). The procedure adopted was to obtain mean values and variances for the different measurements and ratios for males and females of three "phase groups" designated respectively *gregaria*, *solitaria*, and *transiens congregans*. Material of doubtful status was then measured, and its means were compared with these standard means. The view then adopted seems to have been that the morphological indications are of greater importance than any field indications in establishing the phase, although this again was not explicitly stated (cf. pp. 48, 49, 51).

The "phase groups of known origin" are composed of the identical specimens used by Faure (1932). Regarded as standards of comparison, they are therefore subject to the limitations already indicated in discussing Faure's paper [p. 367]. In particular, they are so constituted that no estimate can be made of the variance between different series referable to one phase group. As a consequence, there is no basis for establishing a range of series means which could be regarded as permissible within any one phase group. When a series of unknown status is compared with the standards, a significant difference may be demonstrated between the means, but it remains impossible to determine whether this difference is of such magnitude as to exclude the unplaced series from the phase group with which it has been compared. This difficulty is well illustrated on p. 43 of du Plessis' paper. Du Plessis' position is further complicated by the fact that Faure used morphological criteria, to some extent at least, in selecting material for his standard groups, so that, for example, all material towards the lower limit of *gregaria* has been excluded from the "*gregaria*" group.

Both E and F were found to increase strongly from ph. *solitaria* to ph. *gregaria*. The ratio of sexual dimorphism in E ($E_♀/E_♂$) was found to decrease from 1.35 in *solitaria* to 1.03 in *gregaria*. This ratio was regarded as the best phase character, and "absolute size," of which E was taken as the measure, was placed second. In calculating mean values for E/F, the means of the individual ratios were used. This ratio increased from *transiens* to *gregaria*, but not significantly from *solitaria* to *transiens*. On the other hand, differences in hopper density, even within the category *solitaria*, could give rise to differences in absolute size and sexual dimorphism in the resulting adults.

In the course of laboratory breeding experiments, Vayssière and Lepesme (1939) showed that there is considerable variation in the nymphal coloration of *Schistocerca gregaria* under similar conditions of culture, and concluded that nymphal coloration is too "malléable" to be used in distinguishing the phases, at least in culture material. Moreover there was found to be a marked lack of correlation between the coloration of nymphs and the morphometric characters of the adults to which they give rise. The different morphometric ratios can also give contradictory indications, so that a value for E/F typical of ph. *solitaria* can be combined in the same insect with values for P/C, H/C, and M/C that are almost typical of ph. *gregaria*.

Murat (1939) found a wide range (1.80–2.17) in the values for E/F shown by sparse populations of *S. gregaria* with no swarming antecedents. The top of this range actually exceeds the lower limit proposed by Rao (1937) for the ph. *gregaria*. The higher values were explained on the grounds that the insects had developed under dry conditions, since the populations giving these values were actually less dense than those giving more typical *solitaria* ratios. Different generations had significantly different mean ratios (cf. du Plessis, 1939).

Kennedy (1939), working on the same species, found that sedentary, "near-*solitaria*" populations can show some yellowing on sexual maturation, and some pinkness when freshly moulted (p. 399). However, the yellow color of sexually mature ph. *gregaria* was found to be more amber-tinted. Kennedy's criteria of phase were not very explicitly stated, but it is clear that he regarded the degree of gregariousness as the fundamental one. His observation of a small swarm with mean E/F ratio lower than his "extreme *solitaria*" has already been mentioned. He concluded from this: "Thus it seems that the E/F ratio and other biometric features are unsafe criteria of phase unless account be taken of the stage of given individuals in the whole cycle of outbreak and non-outbreak years. . . A population which appears a fully gregarious swarm may be biometrically 'solitary' if it comes among the early swarms of an outbreak and *vice versa*" (p. 404). Kennedy's very detailed study of the behavior of all three phases led him to conclude that the behavior of even isolated *gregaria* differs from that of *solitaria*. The behavior of *gregaria* is characterized by much increased excitability, and by the possession of a well-developed visual compensation reaction, which is sufficient both to keep members of a band together and to cause them to move parallel to one another; this is the "gregarious instinct proper."

Zolotarevsky (1939), in a study of the phases of *Nomadacris septemfasciata*, compared the morphometric characters of solitary-living locusts, believed to have developed from non-swarming hoppers, with material "provenant d'essaims en migration *et appartenant par conséquent à la phase grégaire*" [italics mine] (p. 72). Material of unknown origin was found to fall into one or other group (on the basis of E/F), and the whole material was then used to calculate mean ratios for ph. *solitaria* and ph. *gregaria*. E/F gave the best separation, followed by P/C, H/C, and M/C in that order. There was also the usual difference in sexual dimorphism, although it was not very marked.

Rao and Bhatia (1939) proposed three ranges of E/F as characterizing the phases of *Locusta migratoria* in India, namely: *solitaria*, 1.90 and below; *transiens*, 1.91–2.00; and *gregaria*, >2.00. These ranges differ from those advanced by Johnston (1934) for *L. migratoria migratorioides*.

Lea and Webb (1939) produced hoppers of *Nomadacris septemfasciata* with a color pattern almost indistinguishable from that of ph. *gregaria* by keeping green hoppers isolated in a hot exposed situation with a small amount of food. These hoppers were not noticeably more active than others which were isolated with plenty of green food and which remained green. The adults produced from them were, however, far from being morphometrically ph. *gregaria*. The authors have referred to the unsatisfactoriness of the categories *transiens congregans* and *transiens dissocians*, in view of the fact that a population may start by dissociating, and later begin to congregate (p. 26). Crowding of solitary-living adults in cages has produced the color of those found in swarms. Circumstantial evidence was obtained to indicate migration of ph. *solitaria* over a distance of a few miles. The attitude of these authors to the question of the definition of phase may be illustrated by the following quotation (p. 30): "... it has been shown that changes in phase are *accompanied by* [italics mine] corresponding changes in morphological characters...."

Smit (1939), in a field study on *Locustana pardalina*, found that the length of the nymphal stage increases from about 25 days in ph. *solitaria* to about 40 days in ph. *gregaria*. Incomplete evidence suggested a larger number of eggs per pod in *gregaria*. This author, like Zolotarevsky (1938b) and others, applied the term "*transiens*" to mixed populations, in which, for example, individuals indistinguishable from ph. *gregaria* in hopper coloration might constitute a substantial proportion of the total.

Klingstedt (1939), in a general review of the Phase Theory from the point of view of its possible applicability to animals generally, stated (p. 4): "Das Wesentliche an den Phasen scheint überhaupt die eigenartige morphologische und physiologische Wirkung einer Stoffwechselveränderung zu sein, deren Ursache in erhöhter Aktivität liegt..."—brought about by mutual stimulation or, possibly, by other factors. In looking around for phase manifestations among insects other than locusts, this author used color and dimorphism in wing length as his chief criteria, and designated forms as ph. *solitaria* or ph. *gregaria* without any reference to their state of gregariousness or even activity. He assigned a phase interpretation to the phenomenon of brachypterism in such Acrididae as *Chorthippus albomarginatus*, *C. parallelus* Zett., *Podisma pedestris* L., and *Dendrotettix quercus* Riley, claiming that the longer wing is correlated with a shorter pronotum more suddenly widened behind. In *C. parallelus* the macropterous forms are said to be most numerous in dense populations; Rehn and Rehn (1938) are quoted as having made the same observation for *Dendrotettix quercus*, although I cannot confirm this from a study of their paper. It should be noted that in these cases we are unquestionably dealing with a very marked reduction in the length of the wings to the point where they become non-functional, whereas the general opinion with regard to the increase in E/F in locusts from ph. *solitaria* to ph. *gregaria* is that this change is due to a reduction in F rather than to an increase in E, relative to the general dimensions of the body (cf. du Plessis, 1939).

In a study of secondary differences between *solitaria* and *gregaria* males in *Dociostaurus maroccanus*, Jannone (1940) found surprising differences in characters usually regarded as not at all plastic, namely the subgenital plate and the epiphallus.

Waloff (1940), in a study of migration in *Locusta migratoria*, found that small groups and separate individuals of both phases migrated farther than large swarms—up to 1700 miles. When these groups or individuals were of ph. *gregaria* they could represent detachments from large swarms, but they could also appear at times of local swarming in the outbreak areas when large swarms did not leave the immediate vicinity of these areas. Waloff concluded (p. 240) that "... long range migrations of phase *solitaria* occur in several, and perhaps in all, species of swarming Acrididae.... The ability to migrate is not restricted to phase *gregaria*...." She used the value E/F = 2.00 as the boundary between *solitaria* and *transiens*, and 2.10 as the boundary between *transiens* and *gregaria*. Her attitude to the definition of phase is shown by her use of the phrase, "the degree of morphological modification *accompanying* [italics mine] phase transformation" (p. 238).

Volkonsky and Volkonsky (1940b), on the other hand, have stated that in *Schistocerca gregaria* migration of ph. *solitaria* is extensive, but not as extensive as that of swarms. Elsewhere the same authors (1940a) presented data showing that, in both sexes of this species, individuals with 6 eye-stripes have a higher mean E/F, and a lower E, than individuals with 7 eye-stripes from the same series.

In a study of eye size in relation to phase in *Locusta migratoria migratorioides*, Thomas (1941) established that the eye is relatively smaller in ph. *gregaria* in both sexes, and expressed this new phase character by the ratios E/D and C/D, D being the height of the eye.

Chauvin (1941) based his determinations of phase, in laboratory material of *Schistocerca gregaria*, upon nymphal and adult coloration. He stated that the eggs laid by females of phase *solitaria* require a temperature of 40°C. for hatching, whereas eggs from *gregaria* females hatch at temperatures below 30°C. Contrary to the results obtained by Smit (1939) on *Locustana pardalina*, the phase *gregaria* was found to develop more rapidly than *solitaria*; individuals of the former phase also weighed less and lived longer, ate much more food, had a lower mortality rate, and a thicker cuticle. *Gregaria* developed melanin in the integument, retained strongly the carotenoids, and especially the xanthophylls, of plants, and contained acridioxanthine in the hypodermis; *solitaria* on the contrary, had no melanin and little or no acridioxanthine, retained carotenoids poorly, and xanthophylls not at all. Even among the progeny of *solitaria* adults, kept completely isolated in green cages, 52 per cent showed a "*transiens*" coloration. A "*gregaria*" coloration could be produced by placing a single *solitaria* hopper in a crowd of the non-swarming *Cyrtacanthacris ruficornis*. Hoppers of typical *solitaria* appearance can occasionally give rise to pink adults with *transiens* morphometric ratios, and sometimes to adults with *gregaria* ratios. Females reared in crowds lose their acridioxanthine and their gregarious instinct as they become senile and may then be regarded as ph. *solitaria* (presumably notwithstanding the possession of *gregaria* morphometric ratios).

In this paper Chauvin uses the term "grégarisme" in a novel sense. Its normal meaning is rendered in English by "gregariousness." However, Chauvin uses it to cover the general characters of the phase *gregaria*: it is, in his own words (p. 235), "un phénomène *sui generis* qui survient chez les criquets groupés, et se manifeste par des modifications pigmentaires et physiologiques variées ... un phénomène physiologique." For the term "gregariousness" in its usual sense, Chauvin uses "instinct grégaire" ("un phénomène de comportement psychologique"). He distinguishes four kinds of this "grégarisme," namely, "larvaire," "imaginal," "sexuel," and "résiduel." "Grégarisme larvaire" is the capacity of nymphs reared in a crowd to develop the black and reddish pigmentation characteristic of the ph. *gregaria*. "Grégarisme imaginal" is the capacity of the male to develop the yellow pigmentation when reared in a crowd. "Grégarisme sexuel" is the faculty possessed by the female of producing offspring of ph. *gregaria* if it is itself submitted to gregarious stimulation. "Grégarisme résiduel" is the tendency of isolated nymphs to remain or become ph. *gregaria* during their development, as a consequence of the "grégarisme" of their parents, and is calculated as 100 per cent minus the percentage of typical *solitaria* hoppers in the fifth instar. Much of this terminology is open to criticism, and in general it has not been followed by later workers.

In a later paper the same author (Chauvin, 1944) employed a biochemical estimation of acridioxanthine per 0.5 g. of body weight as a measure of his "grégarisme." Using an "index solitaire," which bore an inverse relation to the acridioxanthine content, he was able to show that this index was highest in locusts reared in isolation, and lowest in those reared in crowds. However, there was considerable variation in the "index solitaire" among locusts of similar external pigmentation and among locusts of different age, and no attempt was made to establish critical values for the different phases.

Rao (1942), discussing the morphometric differentiation of the phases in *Schistocerca gregaria*, agreed with the conclusions of earlier authors (Zolotarevsky, 1938b; Vayssière and Lepesme, 1939) that "variations in the different characters do not appear to be linked together, but occur independently" (p. 248). Rao introduced the concept of the "biometrical facies" or "constitution" of a given locust population in contrast to the phase of an individual locust. Claiming (p. 249) that "... average biometric ratios ... do not convey any idea of the extent of variation in regard to phase development in the population," he used a "biometrical index" (really a formula) to describe the biometrical facies. This formula shows the percentages of individuals classifiable, on the basis of their individual E/F ratios, as *solitaria*, *transiens*, and *gregaria* (using the E/F ranges assigned to each phase by Rao (1937)), along with the percentages with 6 and 7 eye-stripes. It has the form aS:bT:cG::p(6):q(7). It will be noted that this procedure represented an attempt to obviate the inconsistency, which has been referred to more than once already, whereby one and the same set of terms has been used for the "phase" of a population and for the different "phases" of the individuals composing it (cf. Zolotarevsky, 1938b; Smit, 1939).

Rao noticed a "remarkable parallelism" between the phases *solitaria* and *gregaria* in their life-cycles and migrations, the only difference being the greater activity of *gregaria*, which "owing to its occurrence in swarms is capable, under the influence of mob psychology, of reaching longer distances and covering wider areas" (p. 263). He showed that the value of the width of the head (C) as a phase character attaches only to the width at the gena. The width at the level of the eye (O) does not vary as between phases, and the ratio C/O increases from *solitaria* to *gregaria*.

Volkonsky and Volkonsky (1942) found that young adults of *Schistocerca gregaria*, derived from a swarm and with ph. *gregaria* ratios, but subsequently isolated from the swarm, show very little yellowing on reaching sexual maturity. In a second paper published in the same year, Volkonsky (1942) agreed with Waloff (1940) that migration is not a phase character, but held that it is more extensive in *gregaria* than in *solitaria* (cf. Rao, 1942; Volkonsky and Volkonsky, 1940b).

Faure (1943a) carried out a laboratory study of phases in an army worm, *Laphygma exigua* Hübn. Apparently unaware of the paper by Klingstedt (1939), Faure stated (p. 69): "There appear to be no references in the literature to the discovery of phases in any other group of insects" [than Orthoptera]. This quotation is of interest in demonstrating once again the crucial place accorded by Faure to color and morphology in his conception of phase. There are many species, widely distributed in the animal kingdom, which may be gregarious or non-gregarious according to their abundance or in relation to the reproductive cycle or seasonal conditions, and these differ in their behavior, physiology, and distribution according as they are gregarious or non-gregarious; but these species do not show morphological or color differences correlated with their degree of gregariousness.

Faure classified his larvae according to an arbitrary color scale connecting the extreme types found in isolated and crowded cultures, respectively. At the dark end of the scale, three color types, which were most common in crowded cultures, were classed as "phase *gregaria*"; and at the pale end, two, most common among isolated larvae, as "phase *solitaria*"; intermediate forms were classed as "phase *transiens*." There was no reference to the color of specimens found in swarms and in isolation in the field, and Faure's procedure here is subject to the same criticisms that have already been advanced in connection with Rubtzov's work (1935) on grasshoppers. When larvae reared in isolation were classified in this way, as many as 12 per cent had to be described as "*transiens*," although some of these, amounting to 2 per cent of the isolated larvae, were apparently indistinguishable from "*gregaria*." Of larvae reared in crowds, only 64 per cent could be classed as "*gregaria*," while 8 per cent were "*solitaria*." The larvae in crowds were more active than those in isolation, and the adult moths bred from crowded larvae were slightly darker than those from isolated larvae.

In a second paper, on a more strongly gregarious army worm, *Laphygma exempta* Walk., Faure (1943b) used the same method for establishing his categories of "*solitaria*," "*transiens*," and "*gregaria*," and in this case he got a rather better correlation with the state of crowding. All the crowded larvae were found to be "*gregaria*," and of isolated larvae 62.4 per cent were found to be "*solitaria*," 36.5 per cent "*transiens*," and 1 per cent "*gregaria.*" However, when isolated larvae were reared in darkness, 32 per cent were indistinguishable from "*gregaria,*" and only 12 per cent were classed as "*solitaria.*" Crowds were again noted to be much more active than isolated larvae. In *Spodoptera abyssinia* Guen., a noctuid of minor economic importance, marked color differences were also found between crowded and isolated larvae. Although, on the basis of these, categories designated "*solitaria,*" "*transiens,*" and "*gregaria*" were established, Faure stated (p. 15): "It is rather problematical whether one would be justified in describing this variation . . . as phase variation comparable with that of locusts and army worms . . . for this reason: the fundamentally important factor of increased activity appears to be lacking or very poorly developed in the crowds of this species." However important activity may normally be in the *mechanism* by which the morphological and color characters of the phases are produced, this was the first occasion upon which it had been suggested that this factor should be regarded as fundamental in the *definition* of the phases. Indeed, it had been claimed by several authors who had produced apparently typical phase *gregaria* in locusts reared under artificial conditions that little or no increase in activity was to be noted (cf. Lea and Webb, 1939; Chauvin, 1941).

Duck (1944) crowded nymphs of the non-swarming *Schistocerca obscura* (Fabr.) and found that they developed a color pattern similar to that of the phase *gregaria* in locusts—provided the temperature was not too high.

Husain, Lahore, and Mathur (1944), working on *Schistocerca gregaria,* found that locusts reared in isolation at 27°C. showed E/F ratios characteristic of ph. *solitaria,* but that those reared at 40°C. had ratios characteristic of *transiens* (using the criteria of Rao (1937)). On the basis of their isolation and nymphal coloration, all of these locusts would be referred to ph. *solitaria,* and the authors therefore asked (p. 111): "With what certainty can certain fixed values be assigned to the various biometrical ratios as criteria of the phases of the adults?"

In a field study of *Dociostaurus maroccanus,* Bodenheimer (1944) confirmed the observations of earlier authors regarding the larger number of eggs per pod laid by the phase *gregaria* in this species, and concluded further that in *gregaria* each female lays several egg-pods, each separated by a "maturation flight," while in *solitaria* one egg-pod is the normal number. He stated that this higher fertility of *gregaria* is associated with a higher general vitality, including a lower mortality rate, but he gave no evidence in support of this. In the following quotation (p. 84), Bodenheimer expressed particularly forcefully a conclusion to which his own work, as well as that of many of the authors already considered, must inevitably lead: "But it must always be retained in mind, that neither the morphological nor the chromatic characters of an individual or even of a population permit a conclusion on its behaviour. . . . The decisive criterium will always be the behaviour in the field and this may change within the same generation without leaving definite characters of form or color in the resulting adults."

In discussing the question of isolated locusts with phase *gregaria* ratios, Brédo (1945a) showed that individual *Nomadacris* that become detached from a flying swarm may travel up to 45 miles from the route taken by the swarm before alighting. Such locusts lose their swarming coloration within 3 to 4 weeks and, according to Brédo, should then be regarded as ph. *transiens,* notwithstanding their *gregaria* morphometric characteristics.

Matthée (1945), in an investigation of biochemical differences between the phases in *Locusta migratoria, Locustana pardalina, Laphygma exempta,* and *Spodoptera abyssinia,* as defined by Faure, found that in all species the uric acid content of the blood was higher in ph. *solitaria* than in ph. *gregaria,* while the fat content was higher in *gregaria* than in *solitaria.* Phase differences in lactic acid content, water content, and the pH of the blood were also established for certain of the species.

The same author (Matthée, 1946) confirmed the findings of Faure (1943b) with regard to phase variation in *Laphygma exempta,* including the occurrence of individuals of both "ph. *gregaria*" and "ph. *solitaria*" among material reared in isolation. However, by rearing larvae in isolation for three successive generations, Matthée was able to increase the proportion of "*solitaria*" to a maximum of 82 per cent. He found, further, that "*solitaria*" usually passed through five instars, and "*gregaria*" through six, while the width of the head capsule was significantly greater in "*solitaria*" than in "*gregaria.*" In a further paper (Matthée, 1947), Faure's findings on *Spodoptera abyssinia* were confirmed; intensification of the *solitaria* characters again proved possible by rearing successive generations in isolation.

In the most recent theoretical discussion of the Phase Theory, Zolotarevsky (1946) has exemplified once more that confusion of concepts and definition which has been referred to more than once in the preceding pages, and which is discernible throughout the history of the theory that has been presented. On p. 102 he has stated that density of population is "le facteur essential" in phase transformation, and that one cannot be sure that the morphological changes produced by manipulating such factors as humidity, temperature, food, stimuli, activity, or metabolism, are not "analogue mais . . . indépendante." Yet in discussing the evidence for migration of ph. *solitaria* over great distances (which he largely discounted) he did not hesitate to place absolute reliance upon the morphometric characters of the insects as evidence of their phase. Later he stated that the "nature" of the phenomenon of phases had not yet been defined, nor its place in the "cycle biologique" of living things. The studies carried out up to the present had provided plausible explanations of phase *manifestations*, but had not thrown light on "la notion du phénomène." The manifestations, singly or in combination, were widespread in the animal kingdom, but these were external expressions of deeper phenomena; the phenomenon of phases should be defined in terms of these deeper phenomena rather than in terms of the phase manifestations. Certain of the manifestations were not specific to phases, and the absence of some of the usual ones, including morphological differentiation, did not signify an absence of phase phenomena. (Here we have the complete antithesis of the viewpoint of Faure, for whom phase differences are preeminently characterized by a distinctive type of structural or color modification associated with population density.) Zolotarevsky concluded the theoretical part of his paper with the statement that "le phénomène des phases peut être désigné comme un état biologique instable des individus d'une espèce dont les variations se manifestent par leur physiologie, comportement ou aspect en fonction des modalités de leur interaction."

Michelmore (1947) stated (p. 332) that in *Nomadacris septemfasciata* hoppers of ph. *solitaria* "are sometimes slightly gregarious," and that a concentration of *solitaria* adults may behave as "a true swarm for a few days." He used the expressions "grasshopper phase" and "locust phase" as synonyms for ph. *solitaria* and ph. *gregaria*.

From a comparative histological study of the striped eyes characteristic of ph. *solitaria* in *Schistocerca gregaria*, and the unstriped eyes characteristic of ph. *gregaria*, Roonwal (1947) reached the following conclusions. In the unstriped eye a true apposition image is formed, which is sharply defined; the eye is adapted to vision under intense illumination. In the striped eye a pseudosuperposition image is formed, brighter and more diffuse than in the unstriped eye, so that movements, rather than discrete, sharply-defined images, are perceived; the eye is adapted to vision in subdued light. These characteristics of the eyes affect the clearness with which a hopper can perceive his fellows, thus influencing gregariousness; they are also correlated with the readiness with which *gregaria* hoppers move into open well-lit spaces, compared with the vegetation-frequenting ph. *solitaria*.

Murat (1947) reported "ph. *transiens*" adults of *Schistocerca gregaria* in which E/F had the value characteristic of ph. *transiens*, while the other morphometric ratios, the sexual dimorphism ratio, and the coloration were found to be very close to ph. *solitaria*.

The Mechanism of Phase Transformation

It will be recalled that at the time of the publication of Uvarov's book in 1928 the mechanism of phase transformation was visualized somewhat as follows: multiplication of ph. *solitaria* in special localities leads to crowding, which in turn leads to increased activity. High activity leads to the deposition of black pigment in the cuticle of the hoppers, as a result of which their body temperature (in the sun) is raised, and their activity is consequently still further increased. As a result of the crowding the gregarious instinct is awakened, and this perpetuates and increases the condition of crowding. Thus a vicious circle is set up which leads to the development of the characters of the extreme phase *gregaria*.

Faure (1932) ascribed the increased activity of crowds to mutual stimulation, chiefly tactile, and explained the metabolic effects of high activity by postulating a metabolite "locustine," which is produced in active hoppers or adults, giving rise, in the former, to the characteristic *gregaria* color pattern, and capable of being transmitted to the progeny of active adults in the egg-yolk. He ascribed the morphometric characters of ph. *gregaria* to mechanical effects of continual muscular contraction.

The assumption of an increased body temperature in black hoppers exposed to solar radiation was confirmed by Hill and Taylor (1933) and by Strelnikov (1936), but its significance in increasing activity was questioned by Key (1936), on the ground that what is gained toward the lower temperature threshold of activity might be lost at the upper threshold, when black hoppers could be expected to seek out shaded situations at a lower air temperature than pale hoppers. This point of view was to some extent confirmed by Kennedy (1939), although his data are not well adapted for a separation of activity effects due directly to body temperature from those due to increased excitability.

On the basis of field studies by Uvarov (1932) on *Dociostaurus maroccanus*, Zolotarevsky (1933) on *Locusta migratoria capito*, and others, Zolotarevsky (1934) was able to establish the general conditions of phase transformation in the special localities (outbreak centers) in which alone that transformation is possible. The first of these conditions is an unstable climate, allowing of tremendous increases in the locust population from time to time. As a rule, such increases do not in themselves produce the degree of crowding necessary for transformation into the ph. *gregaria*, and a further condition, namely, a restriction of favorable locust habitats to patches of limited area within a relatively unfavorable terrain, is required. These general conditions for phase transformation could take on very different forms according to the species of locust and the geographical region. Moreover, various other factors, such as the degree of synchronization of hatching, have a bearing upon the outcome in particular cases.

Very similar views on the general mechanism of phase transformation in the field were expressed by Uvarov (1937), although he tended to place greater emphasis upon a *reduction* in the size of favorable habitats resulting from adverse climatic factors, and the consequent active concentration of locusts into them. According to this scheme a period of favorable weather leads to multiplication; this is followed by an unfavorable period leading to restriction of the favorable habitats, concentration of the now large locust population within them, and consequent transformation into the phase *gregaria*. In this paper Uvarov repeated his earlier view that once phase transformation has commenced it is obliged to continue with increasing intensity, unless the swarms are broken up by external agencies; in that case the scattered remnants, no longer stimulated to activity by their fellows, revert to the ph. *solitaria*.

Detailed studies of the ecology of various species of locust in their outbreak areas by Smit (1939), Kennedy (1939), Volkonsky (1942), Bodenheimer (1944), and others, have largely confirmed the general theories of Uvarov and Zolotarevsky as summarized above, and have extended them in various directions.

Kennedy (1939), working on *Schistocerca gregaria*, was mainly concerned with the process of "concentration," as understood by Uvarov, and with its behavior consequences. He found that morphometric changes lagged behind activity changes, and activity changes behind changes in color and gregariousness, in both directions of phase transformation. He divided what he termed the "outbreak process" into three stages (p. 406): (a) "concentration," of which two distinct types were of significance; (b) "aggregation," defined as "the grouping of concentrated individuals in contact with each other so that fellow-individuals assume an increasingly important part in the sensory experience of each locust"; and (c) "gregarisation," defined as "the change of phase (appearance of gregarious behaviour and coloration), the result of intensive aggregation." Both concentration and aggregation were found to be produced entirely by external factors acting on each locust individually. The first stage in gregarization is habituation to fellow-locusts, and is passed through by hoppers that are exposed repeatedly to aggregation. It involves a discriminative refinement of the visual compensation reaction, which may be seen in crude form in ph. *solitaria* in its visual attraction to vegetation. In the second stage, activity and excitability gradually increase. If good habituation has been attained (first stage) before activity reaches a high level, bands leaving the zone of concentration would maintain their coherence. Activity could then increase still further, thus increasing migration range.

Volkonsky (1942) arrived at a conception of phase transformation in *Schistocerca gregaria* which differed in some important details from Kennedy's, but preserved the essential feature of a number of distinct stages, of which the major ones were readily reconcilable with those of Kennedy. In particular, Volkonsky found both an interaction between hoppers, and a resulting increase in activity, at a much earlier stage in the whole sequence of events than did Kennedy. Zolotarevsky (1946) criticized both Kennedy's and Volkonsky's delimitation of stages, and proposed a formulation of his own involving three stages: "pullulation," "prégrégarisation," and "grégarisation."

Bodenheimer (1944), working on phase transformation in *Dociostaurus maroccanus*, was able to apply Kennedy's scheme with little modification. He found that in this species also "the morphological features of phase transformation lag very distinctly behind the transformation of behavior" (p. 77). The morphological changes also lag behind the increase in fecundity, to which, along with the increase in "general vitality" said to be associated with it [p. 377], Bodenheimer assigned an important role in the outbreak process in *Dociostaurus*. In this connection Bodenheimer has provided evidence in favor of an assumption made by Uvarov in 1921, but subsequently abandoned by him [pp. 364, 365, 366]. Bodenheimer stressed particularly the role of climatic factors in promoting or hindering such processes as aggregation, and thus influencing phase transformation in an indirect way.

Apart from these investigations of the normal course of events in the field, a considerable amount of laboratory and other work has been carried out with the object of elucidating the mechanism of phase transformation by analyzing the factors of crowding and high activity, and by inducing one or other aspect of phase transformation by artificial means. The first experiments of this kind were carried out by Faure (1932), who claimed to have shown that the color pattern characteristic of phase *gregaria* can be produced in isolated hoppers of *Locustana pardalina* that are forced into abnormal activity in a special apparatus. His findings were supported by Husain and Mathur (1936a), who showed, moreover, that the *gregaria* pattern can be produced by placing individual hoppers of *Schistocerca gregaria* in crowds of non-swarming grasshoppers. We have already noted that the same authors (Husain and Mathur, 1936b) found that the pattern of phase *gregaria* can be produced in isolated hoppers reared in an atmosphere containing about 3 per cent CO_2.

Johnston (1937) reported (p. 3) that "field observations in Uganda have suggested that food scarcity leading to movement may be sufficient to influence the phase of single nymphs [of *Schistocerca gregaria*] leading them to become in structure ph. *gregaria*." A tendency in this direction, produced by dry conditions, had already been found by Zolotarevsky (1933) in *Locusta migratoria capito* [p. 368], and was later confirmed by Zolotarevsky and Murat (1938) and Murat (1939) for *Schistocerca gregaria* [pp. 371 and 373]. Similarly, Lea and Webb (1939) produced "*gregaria*" hoppers by isolating green hoppers of *Nomadacris septemfasciata* in a hot exposed situation with a small amount of food [p. 374], and Husain, Lahore, and Mathur (1944) produced adults of *Schistocerca gregaria* with E/F ratios characteristic of the phase *transiens* by rearing hoppers in isolation at 40°C. [p. 377]. The suggestion of Pasquier (1938), that the different degrees of expression of the characters of "extreme *gregaria*" in material of *Dociostaurus maroccanus* from different outbreak areas may be due to "ecological variation," i.e., to the effects of physical factors and food supply, has already been mentioned [p. 372].

Chauvin (1941) criticized the work of Faure (1932) and Husain and Mathur (1936a), in which the *gregaria* coloration had been produced in isolated hoppers placed in an activating apparatus, on the grounds that in both cases these isolated hoppers were able to see other hoppers. His own work on *Schistocerca gregaria* had shown that the *gregaria* pigmentation can arise from the association of only two or three hoppers provided they can see each other. He carried out experiments of his own with an activating apparatus in which the individual hoppers were prevented from seeing each other, and found that ph. *gregaria* hoppers became *dissocians* as the experiment proceeded. On the basis of this result and of his observation that locusts in crowds were very little more active than isolated ones, he concluded that activity is only a result, and not a cause of "grégarisme." In support of this view, Chauvin pointed out that *Schistocerca gregaria* is the least active of the major locusts, and yet it develops the *gregaria* pigmentation more readily than any of the others. Further, the assumption that the close proximity of gregarious locusts will lead to increased activity was not supported by findings on other animals, in which activity is sometimes greater, sometimes less, in crowds. The high activity of locusts in the phase *gregaria* is, in fact, a character specific to this group. From these and other considerations, Chauvin concluded that the pigmentary phase differences in *Schistocerca gregaria* are not the consequence of differences in activity, but are of the nature of a reflex response to sensory impressions of fellow locusts effected through nervous mechanisms, endocrine mechanisms, or both.

"Grégarisme larvaire" [p. 375] could be evoked by either visual or tactile impressions. In the case of visual impressions, *movement* of fellow locusts was necessary, and a factor of *recognition* was also involved, since only members of the Acrididae served to elicit the reaction. "Grégarisme imaginal" could be produced in adult male locusts of any phase subjected to crowding, even in the absence of females. It did not occur in castrated males, was the result of tactile stimulation received largely through the antennae, and probably depended upon an endocrine rather than a nervous mechanism. "Grégarisme sexuel" was due to stimulation of the female prior to oviposition, even in the nymphal stage. The longer the total period of stimulation, even at rather widely separated intervals, the greater the percentage of *gregaria* first-instar nymphs in the progeny. Chauvin favored some such explanation as the "locustine" theory of Faure (1932) for "grégarisme sexuel" and "résiduel."

It will not be possible to evaluate the significance of Chauvin's work in the present paper. Certain of his conclusions are arguable on various grounds, and further work on other species of locusts is clearly needed. There is no doubt, however, that he has indicated a possibility that could require a drastic revision of our views on the mechanism of phase transformation.

Following upon the suggestion by Faure (1932) that the structural characters of ph. *gregaria* may be due to the constant pull of the muscles upon the exoskeleton in an insect exhibiting a high degree of activity, Uvarov and Thomas (1942) studied the thoracic muscles of *Locusta migratoria*, and found that the muscles whose contraction might be expected to produce the deformations of the pronotum characteristic of the phase *gregaria* are those concerned in movements of the head and pronotum in relation to the body, and of the first pair of legs. The authors pointed out that in ph. *gregaria* much more time is spent in a horizontal position on the ground than in ph. *solitaria*, and that consequently more muscular exertion is required to support the large head; contraction of the muscles of the legs, including the first pair, must obviously be greater in ph. *gregaria* than in ph. *solitaria*.

The Relation of the Phases to the Development of Outbreaks and their Periodicity

In presenting his Phase Theory, Uvarov (1921, 1928) made it abundantly clear that he regarded the phenomenon of phase transformation as the fundamental cause of the development of locust outbreaks and their periodicity. Typical quotations illustrating this point of view have already been given [pp. 364, 365]. Briefly, phase transformation played this role because: (a) it resulted in an increased reproductive potential; (b) it resulted in migration and invasion of new areas; and (c) its nature was such that once it had commenced it was bound to continue with increasing intensity. The claim that transformation into the phase *gregaria* involves an increase in reproductive rate was later abandoned (Uvarov, 1937), although it has been substantiated since for two species of locust (see Bodenheimer, 1944; Smit, 1939). Ample evidence has already been quoted to show that migration is not an attribute peculiar to the phase *gregaria*, although it is more pronounced in that phase; migration, therefore, is not dependent upon phase transformation. Finally, as will be shown below, there is much evidence that phase transformation is readily arrested or reversed by various environmental factors.

Notwithstanding this weakening of the basis of the theory of the relation of phases to outbreaks, Uvarov's original views on this question have been restated with little modification, both by himself and other leading locust workers, right up to the present time. Thus Uvarov (1937) held that Zolotarevsky's field researches had "confirmed the connection between phase transformation and mass outbreaks" (p. 1), and that "the irregular periodicity of swarming in locusts cannot be studied without paying due regard to phases" (p. 6). Later (Uvarov, 1944) he wrote (pp. 97–98): "The periodicity of locust outbreaks is closely connected with the periodical transformation of the harmless solitary phase into the dangerous gregarious one.... The [phase] theory has supplied the key to the whole problem." Faure (1937) went even further when he stated (p. 799): "The phase theory is the foundation on which our present conceptions of locust biology rest."

This view of the crucial part played by phase transformation led to a redefinition, in terms of phases, of what had previously been referred to as the "permanent breeding grounds" of a locust. Thus the "outbreak areas," i.e., "des lieux où les espèces d'acridiens vivent en permanence et d'où elles entreprennent leurs migrations pendant les années de développement en masse" (Zolotarevsky, 1934, p. 62) were defined by the Third International Locust Conference in 1934 as "all the centres of outbreaks" (Resolution 3(d)3); and the "outbreak centre" was defined as "a station the ecological conditions of which sometimes *provoke the transformation of a species into its swarming phase* [italics mine] (phase *gregaria*)" (Resolution 3(d)4). Zolotarevsky (1934) was able to state at this time (p. 62) that "la théorie de phases ... est à la base de notre conception actuelle des 'aires grégarigènes' . . ."; and almost identical views were expressed much later by Brédo (1945b) and Michelmore (1947).

The stress placed by Uvarov on the concept of the "vicious circle" in phase transformation, the assumption that once phase transformation has commenced it can only continue with increasing intensity, led to investigations designed to permit the separate recognition of the phases *congregans* and *dissocians*. The idea behind these investigations was that, if *congregans* and *dissocians* could be distinguished by examination of a series of specimens, "it would be an enormous practical advantage, for this would enable the entomologist to predict whether or not swarming is to be expected" (Faure, 1932, p. 299). Lean (1936) and Zolotarevsky (1938b) both claimed to have succeeded in differentiating *congregans* and *dissocians* in *Locusta migratoria migratorioides* on the basis of structure and color [pp. 369, 371, 372], although their results were in conflict, and of uncertain significance. Du Plessis (1939) also proposed a basis for separating *congregans* and *dissocians* in *Locustana pardalina*. Other authors (e.g., Lea and Webb, 1939) failed to find any reliable differences between *congregans* and *dissocians*. Roonwal (1945) put forward three hypotheses for predicting swarming in *Schistocerca gregaria*, based upon an analysis of the percentages of forms with six and seven eye-stripes among the males and females of non-swarming populations. All of these attempts to distinguish between the two categories of the phase *transiens*, whether they were successful or not, depended for their main significance upon the assumption that an observed trend in phase transformation would necessarily be maintained in the same direction.

Uvarov's views on phase transformation and locust epidemiology were not accepted by all locust biologists. Thus Olsuf'ev (1930), while accepting the transformation of locusts (*Locusta migratoria migratoria*) into the gregarious phase under the influence of crowding, regarded this as simply a result of the increase in numbers, and not a factor constituting the actual cause of the periodicity. Tarbinskiĭ (1932), who was primarily concerned with *Dociostaurus maroccanus*, expressed closely similar views.

A number of other authors who adopted Uvarov's point of view nevertheless brought forward observations and conclusions which were, in one way or another, at variance with it. Thus Zolotarevsky (1938a) concluded (p. 262): "L'apparition des insectes de la phase grégaire sur une station ne signifie pas encore le début d'une invasion massive." Elsewhere the same author (Zolotarevsky, 1938b), referring to the occurrence of the phase *gregaria* of *Locusta migratoria* under "des conditions particulières" in certain oases in Tchad, suggests (p. 137) that "les bandes n'atteignent pas une importance qui entrainerait des migrations." In these cases transformation into the gregarious phase did not result in outbreaks. Jannone (1938) suggested that in *Dociostaurus maroccanus* the periodicity of outbreaks may be due both directly to the transformation of phase, and indirectly to meteorological and other factors affecting density.

Du Plessis (1939) reported that at a time of active incipient swarming by *Locustana pardalina*, "cases of dissociation of hopper bands were also commonly observed" (p. 10), for which the hot, dry weather and a gradual desiccation of the vegetation were held to be responsible. Zolotarevsky (1938b) had also (p. 213) envisaged the possibility that a population of the phase *congregans* of *Locusta migratoria migratorioides* might be submitted to dissociation before it could reach the phase *gregaria*, and on p. 224 he suggested that a high humidity, by reducing activity and the interattraction of individuals, might have a dissociating effect upon gregarious bands. Smit (1939), working on *Locustana pardalina*, also found (p. 102) that the supervention of environmental conditions depressing activity may reverse an original trend of transformation from *solitaria* to *gregaria*. Lea and Webb (1939), discussing the difficulty of applying the terms *congregans* and *dissocians* to ph. *transiens* hoppers of *Nomadacris septemfasciata*, pointed out (p. 26) that in 1936 small hopper bands first dissociated during the early instars, and later, in the final instar, congregated again. Kennedy (1939) referred to the fact that the environment of the outbreak center of *Schistocerca gregaria*, while favorable to the initial stages of gregarization, brings about dissociation of any incipient bands that do not succeed in breaking out of it. Volkonsky (1941) quoted a case from North Africa in which a considerable degree of gregarization of *Schistocerca gregaria* in 1939 was completely neutralized through mortality induced by climatic factors in 1940, so that the population was pushed back into the phase *solitaria*.

It should perhaps be emphasized that in this fourth section of the account of the history of the Phase Theory we have not been concerned with the views of authors on the general phenomenon of outbreaks, but only with the relation of the phases to the development and periodicity of outbreaks. For this reason the role of multiplication has not been mentioned, although it was dealt with in the preceding section. Multiplication has certainly been accorded an important role by all workers, but the prevailing view has been that its effects are exercised through the resulting phase transformation, without which multiplication would not lead to outbreaks.

DISCUSSION OF CONCEPTS

"Phase"

We have seen how the term "phase" was introduced by Uvarov to designate an "infra-specific category" of a particular kind. It was to designate the "type" of the insect with reference to a continuous range of possible types produced by different levels of gregariousness (including zero gregariousness). The term "type" has to be construed in the broadest sense to include both physical and biological characters. The physical characters were the first to attract attention, and because of their permanence in preserved material have always been accorded considerable significance, but the biological characters are generally regarded as the more fundamental, and also of the greatest practical importance.

It is particularly important to note that the term "phase" was originally used, *not* for the level of gregariousness itself, nor to designate individuals exhibiting a particular level of gregariousness, but for the "type" of individual, in the wide sense indicated above, characteristic of populations possessing a particular level of gregariousness. This statement can be amply supported by a perusal of the quotations already given from the earlier papers of Uvarov, Zolotarevsky, and especially Faure [p. 367]. Thus the concept of "phase" is closely analogous in its structure to that of "ecotype" (more accurately, "ecophenotype"), although the phenomena themselves are quite distinct. "Ecotype" is used to designate, not the individuals of a plant (or animal) species occupying a particular habitat, but the "type" of individual (usually recognized by its physical characters) characteristic of populations occupying that habitat. Similarly "sun leaves" and "shade leaves" are not leaves normally exposed to the sun or shielded from it, but the types of leaves normally found in such situations, and distinguished by their form and structure. As a consequence of these features of the definition of "phase," it follows that, once the type of insect appropriate to the various levels of gregariousness has been determined, the phase of any individual can be established by a study of its individual characteristics, *quite irrespective of the degree of gregariousness it happens to be exhibiting at the time.* Moreover, if there is any conflict between the indications given by the character of the individual on the one hand, and its present level of gregariousness on the other, the character of the individual must always be the decisive consideration, since phase is defined as the type of individual *characteristic* of a particular level of gregariousness, and not as an individual exhibiting a particular level of gregariousness at a given moment.

While these implications of the definition of "phase" have in general been accepted by workers on phases, this has not been invariably the case. Thus Kennedy (1939), when confronted with a "fully gregarious swarm" of individuals with the recognized characteristics of ph. *solitaria*, could not bring himself to call this simply a swarm of *solitaria*, but contended instead that biometric characters are unsafe criteria of phase [p. 373]: see also Husain, Lahore,? and Mathur (1944) [p. 377].

After it had been demonstrated that the phase differences between individuals from swarms and non-swarming populations are due to differences in population density, the phase concept tended to be linked with population density rather than with gregariousness, and we find Rubtzov (1935), Chopard (1935), Klingstedt (1939), and others [pp. 368–368–369, 369, 374] referring to phase phenomena in non-gregarious insects subject to marked fluctuations of population density. When, further, it was concluded that activity is the significant factor in crowding, Faure (1943b) expressed a doubt as to whether one could properly speak of phases in *Spodoptera abyssinia*, because this factor could not be demonstrated [p. 377]. Finally Zolotarevsky (1946) defined phases as variations due to different levels of "interaction" (presumably *behavior* interaction) between individuals [p. 378].

The increasing importance attached to the biological differences between the phases, as distinct from their physical differences, was carried to its extreme by Zolotarevsky (1946), when he maintained that even a complete absence of "morphological" (presumably including color) differentiation does not necessarily signify an absence of phase phenomena [p. 378]. When this attitude is contrasted with that of Faure, for whom morphological differences, color differences, or both, were essential to the phase concept [pp. 367, 376], we are led to wonder whether there is anything really specific to the Phase Theory apart from the physical aspect. This question will be taken up again later [pp. 400 et seq.].

The Phases "Solitaria", "Gregaria," and "Transiens"

The concept of phase as the type of individual produced at a given level of gregariousness implies that there can be as many distinct types or phases as there are levels of gregariousness. A complete gradation of types extends from the one extreme of complete isolation to the other extreme of intense gregariousness. However, for practical purposes it was desirable to distinguish the types associated with sparse populations that could have had no immediate swarming antecedents from those associated with well-developed swarms. Uvarov and Zolotarevsky (1929) have proposed that this should be done by the use of the terms "*phasis solitaria*," "*phasis gregaria*," and "*phasis transiens*" [p. 366]. "*Phasis solitaria*" was to be applied to "the extreme form" represented by isolated individuals with no immediate swarming antecedents, and "*phasis gregaria*" to "the extreme form found in dense, large, emigrating swarms."

It may be noted, in passing, how these definitions, with their use of the term "form," and the latinized and italicized names for the phases, support the interpretation of the concept of phase set out above. Less formal general terms were in vogue before 1929, e.g., solitary phase, dispersed phase; gregarious phase, swarming or swarm phase, migratory phase. Some of these continued to be used after the publication of Uvarov and Zolotarevsky's paper, particularly "solitary phase" and "gregarious phase," and Michelmore (1947) even introduced the inappropriate expression "grasshopper phase."

It is obvious that the expression "extreme form" used in the definitions of Uvarov and Zolotarevsky cannot be taken literally. Strictly speaking, the extreme form in either direction would be represented by a single specimen. Of course nobody adopted this interpretation, but the stress upon extremes interfered for some time with the clear recognition that not only the ph. *transiens*, but also ph. *solitaria* and ph. *gregaria* include a range of types, and that a definition of these ranges, no doubt to some extent arbitrary, is required before the terms *solitaria*, *gregaria*, and *transiens* can be given any very definite signification. Lack of clarity on these points is responsible, for example, for the difficulties into which Faure (1932) and du Plessis (1939) were led in attempting to determine the phase of their field and laboratory material [pp. 367, 373].

The formal establishment of the three phase categories resulted in a particular connotation of the term "phase," so that "*a* phase" came to mean one of the three categories, and assigning an individual to its phase meant placing it in one of the phases *solitaria*, *gregaria*, or *transiens*.

It can be seen at once, from the accepted definition of "phase *gregaria*," that that phase cannot occur in any insect that does not, at some time or other, form "dense, large, emigrating swarms." By definition, therefore, a "grasshopper" cannot possess a phase *gregaria*, although it can show phase variation. Moreover, it would not be justifiable to survey the range of types of an insect produced by cage rearing at different population densities and to assign the term *gregaria* to that part of the range corresponding to very crowded conditions, as has been done by Rubtzov (1935) and by Faure (1943a, 1943b) [pp. 369, 376]. Yet Rubtzov's use of terms was endorsed by the International Locust Conference of 1936 [p. 370], the terminological inconsistency having apparently escaped notice. One could, of course, entertain a redefinition of the phase terms to allow "ph. *gregaria*" to be applied to the types that characterize the densest populations of any species showing phase variation, but such a redefinition has never been proposed, and would very probably create more difficulties than it would solve. On the other hand, it is my opinion that the requirements for ph. *gregaria* might well be somewhat relaxed, and that it might be defined in more general terms as the type characteristic of swarms, i.e., of populations showing clearly marked gregariousness. This would allow the use of the term in the case of the so-called "gregarious grasshoppers." The adoption of this definition would not affect the limits of the phases in locusts, because it could justifiably be maintained that in them the type of individual characteristic of swarms is that found in the dense migrating swarms, rather than in loose incipient swarms, which latter are normally only transient formations destined shortly either to break up or to become dense and migratory. In the case of grasshoppers that do not form swarms, but nevertheless show some degree of gregariousness, with associated phase change, the term "*transiens*" might appropriately be used for the phase of the slightly gregarious individuals. Such individuals conform to the definition given by Uvarov and Zolotarevsky of ph. *transiens* [p. 366], except that they are transitional to a hypothetical, rather than an actual, ph. *gregaria*.

The formal distinction made by Uvarov (1928) between "locust" and "grasshopper," chiefly on the basis of the absence of gregariousness in the latter, has done little to promote clear thinking on the subject of the injurious Acrididae. In the same publication in which the distinction was made, the author admitted that no hard and fast line can be drawn between the two categories: that some grasshoppers are sometimes gregarious, and that all locusts behave like grasshoppers when in the solitary phase. Whatever value the distinction may have depends upon the possibility of describing a given species of acridid as either a locust or a grasshopper, however arbitrary such a classification may be in particular border-line species; but certain authors have confused this classification of species with the distinction between the phases, and have spoken of the solitary phase of a locust as a "grasshopper," or as the "grasshopper phase". Further, the restricted connotation of both "locust" and "grasshopper" has left us with no common term to use on the the numerous occasions when we wish to make a general statement applicable to both groups, and we are forced to employ the clumsy expression "locusts and grasshoppers," or the technical term "Acrididae." In the same way the introduction of the term "band" for a swarm of hoppers, and the restriction of "swarm" to the flying stage (Uvarov, 1928) has left us with no general term for gregarious aggregations of either stage. This sacrifice has been made to very little purpose, since it is usual for authors to employ redundant constructions such as "hopper band" and "swarm of adults" whenever it is necessary to avoid misunderstanding as to the stage involved. It would have been better to have retained "swarm" as a general term, and to have qualified it when necessary with the words "hopper," and "adult" or "winged."

The "Phases" "Congregans" and "Dissocians"

According to Uvarov and Zolotarevsky (1929), the term "phasis *transiens*" is "to be applied to the form occurring in a given locality when the species is on the increase and its individuals are beginning to form loose aggregations, or on the decrease, and the swarms are becoming loose and tend to scatter. . . ." This term should be replaced by "ph. *congregans*" or "ph. *dissocians*" when the direction of change is known. Moreover, observations by the junior author (Zolotarevsky, 1929) had tended to show that *congregans* and *dissocians* could be distinguished by minor details of morphology and coloration [pp. 366, 367].

Now in the terms "phase *congregans*" and "phase *dissocians*," "phase" is being used in a new sense. The term was introduced to designate types of individual characteristic of different levels of gregariousness, but "*congregans*" and "*dissocians*" could have the same level of gregariousness, and differ only in the *direction of change*. Further, the possibility of differentiating between individuals of "*congregans*" and "*dissocians*" is crucial to the question of whether these categories should be called phases, and not merely incidental, as is suggested by Uvarov and Zolotarevsky's wording. As a matter of fact, this possibility is still to some extent in doubt, even for the species with which Zolotarevsky was chiefly concerned [pp. 371, 372, 382], and the terms *congregans* and *dissocians* have been freely used by a number of authors who have claimed that no differences can be detected between them. Thus whatever terms may be used to distinguish "congregating" from "dissociating" individuals, these categories cannot be called "phases" without introducing an undesirable ambiguity into our terminology. The actual terms "*congregans*" and "*dissocians*" could, of course, be retained, and could be used in association with the term "phase *transiens*" in the form "ph. *transiens* (*congregans*)" [not "ph. (*transiens*) *congregans*"], provided it were clearly realized that "*congregans*" and "*dissocians*" represent a supplementary description of the material on the basis of direction of change, and are not themselves phase terms. However, the readiness with which phase transformation in either direction can be arrested and reversed [p. 382] is an argument against the use of any formal terms to distinguish individuals subject to one or other of these processes.

The "Phase Status" of a Population

From the definition of "phase," and particularly from the fact that phases are to be recognized by color pattern and bodily proportions among other things, it must be clear that "phase" is primarily a property of individuals. A population cannot, strictly speaking, have a phase; it can have size (number of component individuals), areal extent, and other properties, but it cannot have a color pattern or bodily proportions. However, where "phase" is used, in the narrower sense [p. 384], to mean one of the categories *solitaria*, *gregaria*, or *transiens*, it could be applied with little or no ambiguity to a population that is *homogeneous for the phase in question*, but not to one in which even a single individual belongs to a different phase. Unfortunately this point has not been appreciated by all authors, and the term "phase" has, in fact, been widely applied to populations heterogeneous in varying degree. The confusion of concepts is seen most clearly where a population is referred to the phase *transiens*. Thus Zolotarevsky (1938b) has classified certain adult populations of *Locusta migratoria* as "*transiens*" on the basis of the level of gregariousness exhibited by the hoppers from which they developed. When the individuals comprising samples of these populations were examined, it was found that the majority had to be referred either to the ph. *solitaria* or to the ph. *gregaria*, and that comparatively few actually possessed the distinctive characters of the ph. *transiens* [pp. 371–372]. Similarly, Smit (1939) applied the term "*transiens*" to populations containing numerous *gregaria* individuals [p. 374].

Notwithstanding these difficulties, we cannot do without a measure of what we may call the "phase status" of populations (as distinct from the phases of individuals), for it is with populations rather than individuals that both the ecologist and the practical entomologist are concerned. Moreover, statistical considerations preclude a reliance upon individuals in phase studies. It is essential, however, that our measures of "phase status" should be based upon the phase characters of the individuals composing the population, and not upon extraneous considerations, such as its level of gregariousness. A number of such measures are possible, and have in fact been used. One method, which has been applied extensively to hoppers, is to classify each individual in a sample of the population as *solitaria*, *gregaria*, or *transiens*, and then to characterize the population by the percentages of the three phases represented in it. Another method, which is applicable where phase characters susceptible of numerical representation are available (as in adults), is to determine the number of individuals in each of several small ranges of the character in question, and to present the frequency distribution in the form of a table or graph. Alternatively, the mean of the character in question may be used in conjunction with the standard deviation and the range.

Rao (1942), who is perhaps the only author to have expressed clearly the contradictions involved in the use of the term "phase" for both individuals and populations, introduced the expression "biometrical facies" to describe the phase status of populations of adult locusts [p. 376]. The term "phase status" is to be preferred to "biometrical facies," as being of more general connotation.

It may be noted that certain concomitants of phase variation are of such a nature that they can only be studied in populations. Thus the sexual dimorphism in size, which is characteristically reduced in populations of ph. *gregaria* as compared with ph. *solitaria*, requires at least two individuals, a male and a female, for its measurement, and a large number of pairs for accurate determination. Similarly, the percentage of individuals with 6 and 7 eye-stripes respectively can only be ascertained from a population. These are true attributes of the populations rather than characters of individuals, but they do not justify us in speaking of the "phase" of a population. Of the same nature are certain of the criteria developed by Zolotarevsky (1938b) for distinguishing the categories "*congregans*" and "*dissocians*" on the basis of the different rates of change of different morphometric ratios, and of the same ratio in the two sexes, in the course of phase transformation [p. 372].

The Physical and Biological Characters of Phases and their Interrelations

In our discussion so far, we have treated the "type" of an individual, constituting its phase, as though this were characterized by a consistent combination of different physical and biological characters such as occurs in a species or subspecies, although we have recognized, of course, that no sharp line can be drawn between the successive phases of the sequence *solitaria*, *transiens*, *gregaria*. Much the same assumption appears to have been made by the early workers on phases. From 1932 onwards, however, an increasing amount of evidence has been brought forward to show that the correlation between the different characters of any one phase is by no means as close as was supposed.

The characters in which the phases differ may be classified as behavioral, physiological, morphological, and color characters. The more important of those that have been reported for various species are as follows:

Behavior characters: degree of gregariousness, depending upon the degree of development of the visual compensation reaction; degree of excitability; degree of activity (this is not an independent character, but is the result of the interaction of gregariousness, excitability, and, under certain circumstances, pigmentation); frequency and extent of migration; and the relative importance of visual and olfactory stimuli in controlling behavior.

Physiological characters: basal metabolism; biochemical characters, including uric acid, fat, lactic acid, and water contents, the pH of the blood, the development of melanin and acridioxanthine, and the retention of carotenoids; the temperature threshold for hatching of the eggs; the physiology of vision in relation to the histology of the eyes; thickness of the cuticle; specific gravity; fecundity; duration of nymphal development; number of instars; and food consumption.

Morphological characters: absolute size; sexual dimorphism in size; bodily proportions of the adult, as measured by the morphometric ratios E/F, P/C, H/C, M/C, E/S (S = width of sternum), E/D (D = height of eye), and C/O (O = width of head at the level of the eye); and number of antennal segments.

Color characters: nymphal color pattern; various minor features of adult coloration; the nature of the color changes associated with ageing and sexual maturation; and the number of eyestripes.

The early authors on phases used the expression "*biometric* ratio," and this is still the one most generally employed. Pasquier (1934) and certain other French authors have used "*morphometric*," and Jannone (1938) introduced "*somatometric*." Zolotarevsky (1939) commended Jannone's term on the ground that we are concerned only with structural, non-heritable characters. The term "biometric" is clearly ambiguous, since it could refer to measurements of any biological character, including coloration, although, as used by phase workers, it is intended to exclude such characters. It is further rendered unsuitable by its extensive use as a virtual synonym of "statistical." On the other hand, "somatometric" does not restrict the reference to non-heritable characters as Zolotarevsky imagined, but to characters of the soma as distinct from characters of the germ-cells. Needless to say, the characters of the soma are controlled by both genetic and environmental factors. (In point of fact, it is quite impossible to measure, directly, any "non-heritable" character. One can only measure properties of the organism as it stands, although, if proper precautions are taken, it is possible to infer from the measurements the contribution of genetic and non-genetic causal factors.) Further, "somatometric" does not contrast the bodily proportions with color or physiological characters any more than "biometric" does. The only precise term is "morphometric," which signifies measurement of morphological (i.e., external, structural) features. This term is already in use in English-language publications on physical anthropology and vertebrate taxonomy (cf. Schaefer, 1948).

Not all of these characters are involved in phase change in any one species, and indeed some of them are affected in only one or a few species. Occasionally phase change has opposite effects on a character in two different species. Thus nymphal development takes longer in the phase *gregaria* of *Locustana pardalina* (Smit, 1939), and in the phase *solitaria* of *Schistocerca gregaria* (Chauvin, 1941) [pp. 374, 375]. On the other hand, certain characters are involved in phase change in almost every species subject to it, and are always affected in the same way. These characters are, moreover, usually the ones affected to the greatest relative extent, and may be regarded as the phase characters *par excellence*. They include degree of gregariousness, degree of excitability, the E/F ratio, absolute size (at any rate in the male), the sexual dimorphism in size, nymphal pattern, and the tendency to a general yellowing of the body, with a parallel reduction of pattern contrast, in sexually mature males of the phase *gregaria*. Nevertheless the correlation between the degrees of development of even these characters, in different populations of any one species showing a similar level of gregariousness, is so low that Rao (1942) was led to conclude that "variations in the different characters do not appear to be linked together, but occur independently" [p. 376].

To illustrate this lack of consistent correlation, we may draw together the findings of a number of authors already quoted in discussing the historical development of the Phase Theory. With regard to the behavior characters, we note that a high level of gregariousness does not necessarily lead to migration [p. 382], while migration of individual adults over distances nearly as great as those covered by swarms [p. 375], or even over much greater distances [p. 374], has been shown to occur frequently in two species, and may be suspected in others. The morphological characters are not at all closely correlated with each other: numerous authors have found a poor correlation between E/F and the pronotal ratios [pp. 367, 372, 373, 378], and between E/F and absolute size or sexual dimorphism [pp. 373, 378]. Vayssière and Lepesme (1939), in particular, found that a value for E/F typical of ph. *solitaria* could be combined in the same insect with values for the pronotal ratios that were almost typical of ph. *gregaria* [p. 373]; and Lean (1936) showed that in *Locusta migratoria migratorioides* increase in E/F within a series of *transiens* or *gregaria* was at first accompanied by an increase in absolute size, but that after a certain point further increase was correlated with a decrease in size [p. 369]. When we compare the coloration of adults with their morphological characters, we find that sexually mature adults of *Schistocerca gregaria* with morphometric ratios typical of the phase *solitaria* may show the yellow color typical of the phase *gregaria* if they occur in a swarm or are crowded in the laboratory [pp. 371, 373]. Conversely, adults developed in a swarm, and with the morphometric ratios of ph. *gregaria*, will not become yellow if they become isolated from the swarm well before sexual maturity [p. 376]. Similarly the complicated color changes associated with degree of gregariousness in adult *Nomadacris septemfasciata* occur quite independently of the morphometric ratios [p. 371]. The correlation between the color pattern of the nymphs and the morphological characters of the resulting adults is also unreliable, even when there is no appreciable change in density or degree of gregariousness between the nymphal and adult stages. The nymphal pattern is more sensitive to changes in the level of gregariousness than is the adult morphology, so that hoppers described as ph. *gregaria* can give rise to adults with morphological characters of a type normally associated with the phase *transiens* [pp. 367, 373, 374]. Isolated hoppers in which the "*gregaria*" pattern is produced by artificial means give rise normally to adults with the morphological characters of the phase *solitaria* [pp. 370, 374], and conversely isolated hoppers reared at 40°C., which have retained the coloration of the phase *solitaria*, produce adults with the morphological characters ascribed to ph. *transiens* [p. 377]. Typical "*solitaria*" nymphs can give rise to adults with "*gregaria*" coloration and morphometric ratios [p. 375]. Chauvin (1941, p. 254) has stated that there is no correlation between his "grégarisme larvaire," "imaginal," and "sexuel."

The most serious cases of inconsistent correlation are naturally those between the behavior characters, particularly the degree of gregariousness, on the one hand, and the morphological and color characters, on the other; for a lack of correlation here affects the whole of the elaborate system that has been built up for using the physical phase characters as a means of inferring the behavior of populations. It must be conceded at once that there can be no question about the *general* correlation, which has been proved conclusively for all species showing phase variation. But the discrepancies in particular cases are so frequent and so striking as to merit the most careful consideration.

Large, dense, migrating swarms of adults do not always possess the morphological characters normally associated with this level of gregariousness. Faure (1932) excluded a number of such swarms from the material on which he based his characterization of the phase *gregaria* in *Locustana pardalina* because their constituent individuals were found to be of the "*transiens* type" [p. 367]. Other "compact swarms" have been found to consist of "a mixture of *solitaria*, *gregaria*, and transitional forms" [p. 371], and a "fully gregarious" (though small) migrating swarm, morphologically "*solitaria*," has been reported by Kennedy (1939) [pp. 371, 373]. Other authors have referred to the way in which populations with "*solitaria*" morphological or color characters are occasionally observed to congregate and behave gregariously [pp. 371, 378], although they certainly do not produce large migrating swarms.

More numerous are the instances in which isolated individuals, which could certainly have had no immediate swarming antecedents, are found to show the morphological characters normally ascribed to the phase *transiens*, or even *gregaria*. Hot, dry conditions appear to be responsible [pp. 367–368, 371, 373, 377, 380]. Similarly, inj rearing experiments, the color pattern of ph. *transiens* or ph. *gregaria* has been produced in hoppers kept completely isolated under conditions of high temperature, low humidity, and a poor food supply, or even under apparently favorable conditions [pp. 374, 375]. Typical phase *gregaria* adults may become detached from swarms, in which case they may revert to the type of behavior characteristic of the phase *solitaria*, while retaining their *gregaria* morphology [pp. 371, 377].

A similar lack of correlation is found if we study the morphological and color characters in relation to migratory behavior. Individuals with the physical characters of ph. *gregaria* are not necessarily migratory [pp. 371, 382], while those with the physical characters of ph. *solitaria* may on occasion undertake extensive migrations [pp. 371, 371, 374, 374–375, 375, 376, 376].

The position as regards the correlation between physical characters and behavior has been aptly summed up by Bodenheimer (1944) in the passage already quoted [p. 377], in which he has stated that neither the morphological nor the chromatic characters permit inferences as to behavior. It was this lack of correlation that led Lea (1938) to introduce the purely behavioral classification into "solitary-living" and swarming individuals, a classification which thus became contrasted with the primarily physical classification into "phase *solitaria*" and "phase *gregaria*" [p. 371].

The lack of correlation, both between the physical characters themselves, and between these and the behavior characters, especially the degree of gregariousness, is probably due to a considerable extent to the fact that the various characters are affected in what approximates to a definite sequence as the degree of gragariousness increases. Thus some degree of mutual habituation, constituting the beginnings of gregariousness, appears to precede any great increase in activity, and the latter is followed in turn by some of the physiological changes, the color changes, and the morphological changes. Among the morphological changes, the E/F ratio seems to be affected before the pronotal ratios. However, this explanation does little to help us in the problem of recognizing a "type" of individual to which, for example, the term "phase *gregaria*" would apply, because the level of gregariousness represented by "large, dense, migrating swarms" may be reached long before the sequence of changes in the physical characters has been completed, so that one character may already have reached the level characteristic of "*gregaria*," while another is still at the "*transiens*" or "*solitaria*" stage. Moreover, a considerable part of the lack of correlation is not to be explained on the basis of a time lag at all—for example, that resulting from the effects of moist and dry conditions on the development of isolated individuals, or from marked changes in the degree of gregariousness during development.

Attempts have been made to remove some of the difficulties by correlating the physical characters of adults, not with their level of gregariousness at the time, but with the level of gregariousness of the hoppers that gave rise to them: in effect, with their "history of gregariousness." But this only gives rise to fresh difficulties. Although the morphological characters of an adult are conditioned in the hopper stage, its color is chiefly the result of factors operating within the adult stage. Similarly, the black color of newly-hatched *gregaria* nymphs may be referred to their history of gregariousness (parental gregariousness), but their pattern by the third instar is a function of their degree of gregariousness within the hopper stage as well.

The inevitable result of the existence of poorly-correlated criteria, all of which have a claim to consideration in the recognition of phases, is widespread uncertainty and confusion. Thus when Volkonsky (1938) found morphometrically "*solitaria*" adults developing the "*gregaria*" coloration he spoke of a change of phase, as did Brédo (1945a) when he found morphometrically "*gregaria*" adults assuming the "*solitaria*" coloration and behavior; on the other hand, Lea (1938), faced with the same situation as Brédo, spoke of solitary-living phase *gregaria*. Kennedy (1939) was unable to regard his "fully-gregarious swarm" with "*solitaria*" morphology as anything but phase "*gregaria*," although if the same specimens had been encountered in dispersed formation they would undoubtedly have been classed as "*solitaria*."

Chauvin's terminology (1941), involving different categories of "grégarisme" [pp. 375, 381], may be briefly mentioned here. He used this term somewhat ambiguously for *manifestations* of the phase *gregaria*, and also for the *capacity* ("fait," "faculté," p. 248) to show the characters of that phase. A further ambiguity, as we have already seen, arises from the fact that the word "grégarisme" normally means "gregariousness," and thus denotes a purely behavioral characteristic. This ambiguity could be avoided in English by anglicizing the French term to "gregarism" and using this in contrast to "gregariousness," but it is doubtful whether the term is warranted at all. The terms "grégarisme larvaire," "imaginal," "sexuel," and "résiduel" do not describe distinct *gregaria* characters so much as distinct mechanisms whereby either the same or different characters may be produced, and for this purpose the terms are poorly chosen. Thus "grégarisme larvaire," "sexuel," and "résiduel" are all estimated by the nymphal pigmentation, whose character is the same in all three; "grégarisme sexuel," no less than "imaginal," is nevertheless regarded as a property of the adult locust; finally, "grégarisme imaginal" is dependent upon sexual maturation, while "grégarisme sexuel" can be affected by stimulation received during the nymphal, i.e., pre-sexual, period. Whatever value this classification might have for purely physiological purposes, it can be of no assistance in characterizing the phases, and is, in fact, only confusing. Chauvin himself based his determination of phases purely on the pigmentation of the nymphs.

The Characterization of the Phases by Ranges of One or More Characters

In spite of its unreliability in particular cases, there is unquestionably, as we have already noted, a general correlation between the phase characters, and in particular between the level of gregariousness and the other characters. That is to say, there is no question, for example, that the individuals composing large dense swarms tend in general to approximate to the type designated phase *gregaria*. For the purpose of characterizing the three main phases, special attention has been given to the morphological characters, because these are permanent in preserved specimens, and are susceptible of numerical representation. Moreover, so far as valid comparisons can be made, it appears that the morphological characters are as closely correlated with degree of gregariousness as any of the others. The characters chiefly used have been absolute size, sexual dimorphism in tegmen length, the E/F ratio, and the ratios between dimensions of the pronotum and the width of the head. Of all these, the one most extensively employed has been E/F.

In the discussion that follows, the methods used in arriving at this characterization will be examined, and for this purpose we may take E/F as being typical of the various characters used.

Any series of specimens drawn from a population exhibiting a given level of gregariousness will show a variation in E/F. This variation may be ascribed to different causes. Individuals may be more or less responsive to identical levels of gregariousness on account of genetic differences, or of chance differences in vigor or some other character due to their individual environmental history. Alternatively, particular individuals may have been shielded to a greater or less degree from the full impact of the gregariousness of the population as a whole by some chance circumstance, or they may have been submitted simultaneously to other environmental forces which either partly neutralized or reinforced the effect of gregariousness. Further, in spite of all precautions, the series may include specimens which do not properly belong to the population at all, but to some other population exhibiting a very different level of gregariousness.

The best measure of the effect of the level of gregariousness being studied will be the mean value of the character in question, i.e., in the example we have selected, E/F. The extent of the variation within the series, or its "spread," will be given by the standard deviation, and the reliability of the mean by its standard error. These measures are essential if we are to be in a position, in the one case, to determine the chance that an individual with any given value for E/F can be a member of the population sampled; and, in the other, whether another series with a slightly different mean E/F can be regarded as significantly different or not. Yet two successive International Locust Conferences have resolved that the "true average ratio" for a series should be calculated by a method which makes it impossible to determine the standard error, namely, by calculating the ratio of the totals of the actual measurements instead of the average of the individual ratios [p. 368]. Apart from this deficiency of the Conference method, its claim to provide the "true average ratio" cannot bear examination, although it does provide a close approximation to the true average with considerable saving of labor. For if E/F should happen to be positively correlated with absolute size, and if there is any appreciable range of absolute size in the material of the series, then the Conference average will be weighted in favor of the higher values of E/F, and will therefore be higher than the true mean. Those authors who have followed the Conferences' recommendation have sacrificed part of the value of their work, chiefly because it is impossible to determine what significance, if any, should be attached to the differences between their series means.

If sample series are taken from a number of different populations, all at a similar level of gregariousness, but at different times and places, the series means for E/F are usually found to differ significantly, and often considerably. The differences may be ascribed to differences in the levels of factors that modify the influence of gregariousness upon the E/F ratio or that influence E/F directly, quite apart from gregariousness, and also to differences in the level of gregariousness itself that were not apparent to the observer. The variation between such series can be expressed as a range, or by calculating a general mean (mean of the series means) and the interseries variance or standard deviation.

Now in characterizing the three main phases by means of E/F we are concerned, not with three levels of gregariousness, but with three *ranges* of the degree of gregariousness [p. 384]. The phase *solitaria* is the type represented by non-swarming populations ranging from extremely sparse to moderately dense, and the work of Volkonsky (1942) and du Plessis (1939) has shown that we cannot rule out effects of mutual interaction in such populations [p. 373]. The phase *gregaria* is the type represented by large, dense, migrating swarms, or, if we accept the modification of this definition suggested on p. 382, by swarms. Even within the category "large, dense, migrating swarms" there is room for a range of size, density, migratory behavior, history of gregariousness, etc., and this is all the more true of the wider category "swarms." The phase *transiens* covers the types appropriate to a range of gregariousness extending from the first signs of the phenomenon in a non-swarming population to a level just short of what we may designate a "swarm" or a "large, dense, migrating swarm." Thus in characterizing a phase by the E/F ratio, we have to determine series means for a large number of populations representing the whole range of gregariousness appropriate to the phase in question, and the variation between these series means can be expected to be greater than that between means for populations showing apparently the same level of gregariousness. The range of variation in E/F appropriate to a given phase may then be given by the range of these series means, or by a general mean and the interseries variance.

It is essential that the populations to be studied should be selected purely on the criterion of their *degree of gregariousness*. If any other considerations, such as color or morphology, are allowed to influence the selection, we end up, not with a characterization of the phases, in terms of their definition, but merely with a correlation between two phase characters, or, still worse, with something which is, to a greater or less degree, merely a numerical statement of the basis of selection itself [pp. 366, 367, 369, 369, 373]. It is also essential that the means for the different sample series representing a given phase should not be merged into a general mean without any indication of either the range of the series means or the interseries variance. When this is done, we find ourselves in the dilemma of Faure (1932) and du Plessis (1939), who could say that a given series approaches the mean value for E/F characteristic of, say, phase *gregaria*, but never knew whether it enters the range covered by the series that contributes to that mean, i.e., whether it could actually be considered *gregaria*.

Unfortunately, as we have already seen [p. 388], the range of variation even of series means is so wide, even in some of the major locust species, that there is considerable overlap, not only between the values found for adjacent phases in the sequence *solitaria*, *transiens*, *gregaria*, but even between *solitaria* and *gregaria*. That is, it is not always possible to infer with certainty whether a given population is swarming or non-swarming on the basis of the mean morphometric character. Certain extreme values can be interpreted with confidence, but there remains a considerable range within which the interpretation will be ambiguous. In these circumstances we are faced with the alternatives of (a) abandoning any attempt at close characterization of the phases, and with it the possibility of their recognition by generally accepted, objective criteria; or (b) defining a range of series means into which the great majority of the series of a given phase will fall, and using this as a rigid definition of the phase in question, irrespective of the level of gregariousness with which it may be associated in particular cases. Both of these alternatives have their adherents among authors on the Phase Theory, although they have not been consistently followed, and all their implications do not appear to have been grasped. Kennedy (1939), Husain, Lahore, and Mathur (1944), and Bodenheimer (1944) have all, openly or by implication, adopted alternative (a). The majority of authors have followed (b), although they show indecision when faced with insects of "*solitaria*" type behaving gregariously, or with insects with "*gregaria*" ratios living in isolation, and perhaps with no immediate swarming antecedents. Ranges of series means of E/F for each of the phases *solitaria*, *transiens*, and *gregaria* have been proposed by various authors for *Schistocerca gregaria* and several subspecies of *Locusta migratoria* [pp. 368, 369, 371, 374, 375]. In some other species, authors have been content, up to the present, to establish a rough dividing value between *solitaria* and *gregaria*.

In this discussion we have used the ratio E/F as an example of a morphometric character for the purpose of examining the problems involved in using such characters for determining phase. Actually there are not one, but several such characters, and, as we have seen, these are poorly correlated with one another, and may give contrary indications. It is therefore necessary, at any rate if we propose to follow the alternative indicated above under (b), either to select the character that shows the most consistent correlation with level of gregariousness, or else to develop an index that will combine the values of several characters in a single expression.

Several workers have approached the question of determining which of the morphometric characters gives the "best indication" of phase. There seems to be general agreement that in *Locusta migratoria*, *Schistocerca gregaria*, and *Nomadacris septemfasciata* this character is E/F, although no precise statistical study of the question has been made. On the other hand, the rigorous analysis of du Plessis (1939) has shown that in *Locustana pardalina* the best indication of phase is the sexual dimorphism ratio for tegmen length, with absolute size placed second, and E/F much inferior [p. 373]. Jannone (1938) has regarded absolute size as the best character in *Dociostaurus maroccanus*, with E/F next [p. 372]. Unpublished work of my own on the Australian species *Chortoicetes terminifera* (Walk.) and *Austroicetes cruciata* (Sauss.) has shown that in the former the best character is E/F, and in the latter absolute size. Thus the "best" characters are not the same in different species, so that a rigid definition of the phases on the basis of a single morphometric character would involve the use of different characters in different species. It may be noted that the "best indication" of phase in *Locustana pardalina* is not a phase character proper [see p. 386] and could not be used to refer individual specimens to their appropriate phase, although it could indicate the phase status of a population.

As far as the author is aware, no attempt has yet been made to evolve a single index of phase based upon a number of phase characters. Rao's "biometrical index" [p. 376] is not really an index, but a condensed list, in which the two characters used (the E/F ratio and the number of eye-stripes) have not been integrated in any way. A true single index would seem to have distinct theoretical advantages, although from the practical point of view it could involve a very much greater amount of measurement and computation than would the use of the best character alone.

The Mechanism of Phase Transformation

It will be convenient to discuss under this heading concepts and terminology relating to the "outbreak process" [p. 379] as a whole, and not merely those concerned with phase transformation itself; and in this connection we may take the formulations of Kennedy (1939), Volkonsky (1942), Bodenheimer (1944), and Zolotarevsky (1946) as representing the most significant contributions to the subject in recent years. Kennedy classified the outbreak process into three successive stages distinguished by the nature of the processes taking place in each [p. 379]. Volkonsky and Zolotarevsky put forward modified versions of this classification [p. 379], so that we now have three competing classifications in which the same terms are sometimes used in different senses. It would seem that there must always be a certain degree of arbitrariness in classifying a complex process into stages in time, and greater unanimity may be expected in relation to a scheme that represents the individual processes and their interrelations. Such a scheme, in which no new terms are introduced, is presented in outline in Fig. 1.

In that figure the linking of two processes by an arrow is to be interpreted in the sense that the first process is to a greater or less degree a precondition of the second, or at least has an important influence upon it. In general, therefore, processes linked in that way are successive in time, and the time sequence is in the main from the top of the diagram to the bottom. On the other hand the picture is complicated by mutual interaction between certain processes (shown by double arrows), and by the secondary influence of one process upon another earlier in the sequence. The latter effect gives rise to a circuit of steadily intensifying processes, of which the best example is the crucial phenomenon of the "vicious circle" of swarm formation. The diagram owes its chief inspiration to the work of Kennedy (1939), but includes certain relations that were well known before the publication of his study, and others demonstrated subsequently by Volkonsky (1942) and Bodenheimer (1944). Only the major processes and the major interactions are shown.

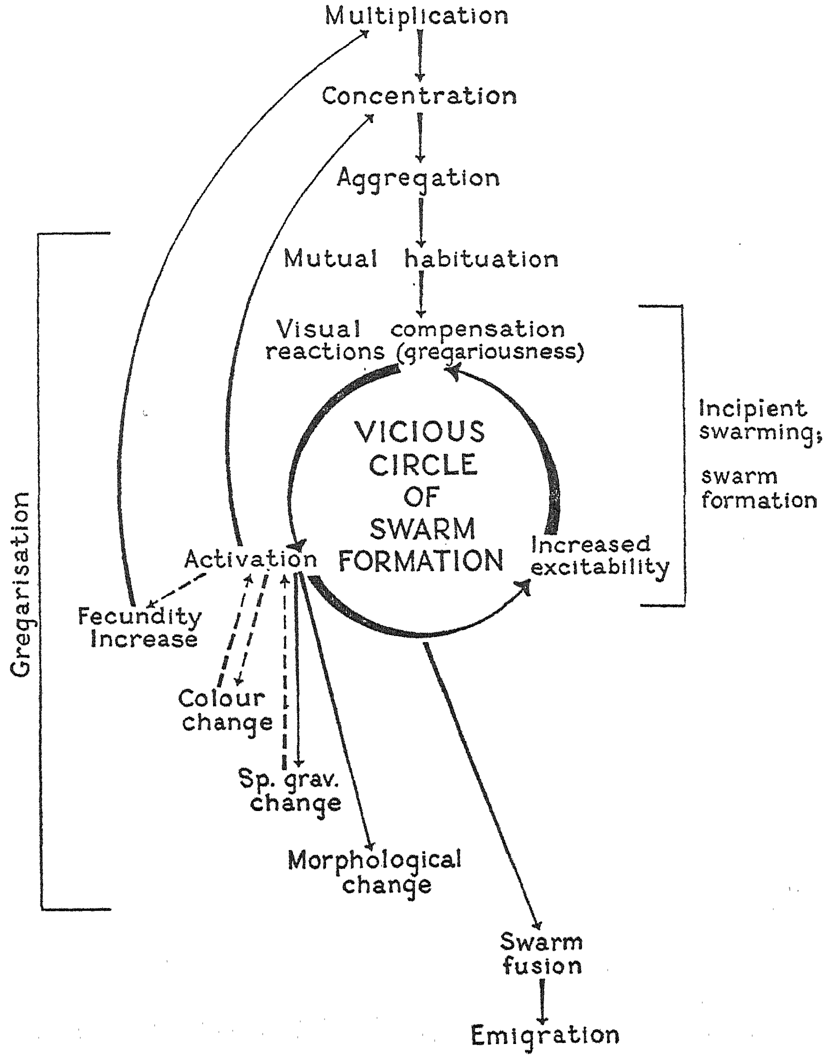

FIG. 1. DIAGRAM ILLUSTRATING THE MAJOR COMPONENT PROCESSES OF THE "OUTBREAK PROCESS," AND THEIR INTERRELATIONS

Arrows connect processes of which the first is to a greater or less degree a pre-condition of the second; broken arrows indicate a doubtful relationship. The time-sequence is in general from the top of the diagram to the bottom.

As has been pointed out elsewhere (Key, 1945, p. 38), the term "concentration" as used by Kennedy covers a heterogeneous group of concepts, of which "virtual concentration" and "apparent concentration" would be more properly included under "multiplication"; on the other hand "aggregation" is in its essence an intensive type of concentration, although it probably merits separate recognition in view of its special relation to gregarization. The outbreak process is thus represented (Fig. 1) as starting with multiplication (including virtual and apparent "concentration" of Kennedy), which is succeeded by concentration ("real" concentration only), and this in turn by aggregation. Aggregation leads, as suggested by Kennedy, to mutual habituation, and a discriminative refinement and strengthening of the latent visual compensation reaction which is the root of gregariousness. At this point a marked increase in activity commences, although a less pronounced activation is to be observed in the earliest stages of aggregation (Volkonsky, 1942). The increased activity results in increased excitability, which may be regarded as a lowering of the stimulus threshold for activity, possibly by some such mechanism as a reduction of synaptic resistance following frequent repetition of a reaction. Increased excitability in turn reacts upon the strength of the visual compensation reaction so as to increase gregariousness, and by so doing completes the "vicious circle of swarm formation." This vicious circle may perhaps be better visualized as a helix rising up vertically from the diagram, each of the three participating processes being raised to ever-increasing levels of intensity.

It seems probable that the increased activity is even more closely connected with the strengthening of the visual compensation reaction than has been suggested by Kennedy. Thus the visual stimulus producing the increased activity may well be the same as that eliciting the compensation reaction, namely, movement of the image of objects across the retina. In that case the activity itself would be compensatory activity and would increase with increasing strength of the visual compensation reaction, both directly, as being the motor expression of that reaction, and indirectly through the effect of the compensation reaction in increasing the population density, and thus the amount of visual stimulation. This would not apply to the smaller increase in activity that arises much earlier, apparently as a result of olfactory stimulation (Volkonsky, 1942).

The increased activity (Fig. 1) permits more efficient concentration and aggregation (Volkonsky 1942), and thus sets up a sort of minor vicious circle subsidiary to the main one. Further, at some stage of the development of the helix, possibly as a consequence of the activation, there occurs in *Dociostaurus maroccanus* (Bodenheimer, 1944), and presumably in *Locustana pardalina* (see Smit, 1939), an increase in fecundity, which leads to a third vicious circle through its effect on multiplication. Finally, when the helix has mounted to a sufficient height, the gregariousness and activity of the swarms become sufficient to permit extensive swarm fusion, and ultimately, emigration.

In comparison with the major processes so far discussed, the classical phase changes in coloration, morphology, etc., appear in the light of mere epiphenomena, and this remains true whether we accept the conventional view that these changes are the result of increased activity, or the view of Chauvin [pp. 380–381] that they are of a "reflex" nature. In Uvarov's early conception of the vicious circle [p. 378] the development of black pigment in hoppers of the phase *gregaria* was assigned an important role through its effect upon body temperature and thus upon activity. However, neither in *Dociostaurus maroccanus* [p. 372] nor in *Chortoicetes terminifera* (unpublished observations of the author) is there any marked difference between the amount of black pigment in the phases *solitaria* and *gregaria*, yet the vicious circle remains. Moreover, developing the argument advanced by Key (1936) [p. 379], it may be seen that the effect of black pigment on the total activity of hoppers will depend entirely upon the relation that exists between the upper and lower temperature thresholds of activity on the one hand, and the average daily temperature regime of the given locality at the given time of year. Where temperatures are low, the higher body temperature of black hoppers could result in considerable increase in both the duration and intensity of activity; but where temperatures are sufficiently high, black hoppers could be expected to seek shade and become inactive well before pale hoppers, and the latter can in this way could have a considerably longer span of activity each day. In this connection the recent observations of Pielou (1948) on the dispersal and "disappearance" of gregarious groups of hoppers of *Nomadacris septemfasciata* at high temperatures are significant. There is, in fact, no real evidence that the black pigment of ph. *gregaria* hoppers plays any significant part in increasing their activity or in promoting the vicious circle of swarm formation.

Of the other phase characters, the reduced specific gravity in ph. *gregaria* has been suggested as a factor making for increased activity (Strelnikov, 1936), and other characters have from time to time been supposed to have some influence upon the vicious circle. Roonwal (1947) has presented evidence indicating that the unstriped eye characteristic of the ph. *gregaria* in *Schistocerca gregaria* is better adapted for producing sharp images of other locusts, and for use in bright sunlight, than the striped eye of ph. *solitaria* [p. 378], so that the appearance of the unstriped eye in the course of phase transformation may promote a further development of gregariousness. However, nothing analogous to the striped and unstriped eyes of *Schistocerca* has been reported in other locusts (apart from *Anacridium aegyptium* (L.)), so that the supposed effect of this phase character cannot be of any general importance.

Altogether, it would seem that none of the classical phase characters, which preeminently distinguish the phases as "types" of individual, play an essential part, or even, perhaps, a significant part, in promoting further phase transformation. The vicious circle of swarm formation appears to be entirely a behavior phenomenon, depending upon the processes of mutual stimulation, visual compensatory activity, increase of excitability, and progressive strengthening of the visual compensation reaction. The classical phase characters are little more than pointers to the stage that has been reached in this process of behavior transformation—and unreliable pointers at that.

The "stages" of Kennedy, Volkonsky, and Zolotarevsky [pp. 379, 380] can be readily recognized in Figure 1. Kennedy's "concentration," Volkonsky's "pullulation locale," and Zolotarevsky's "pullulation" are all to be identified with the first two processes of multiplication and concentration. Kennedy's "aggregation," and Volkonsky's "agrégation" correspond to our process "aggregation." Volkonsky's "prégrégarisation" includes the processes from multiplication to aggregation or mutual habituation inclusive, while Zolotarevsky's use of the same term covers the processes aggregation and mutual habituation. Kennedy's "gregarization" extends from mutual habituation to the stage of dense swarms with ph. *gregaria* characters, while Volkonsky and Zolotarevsky employed this term for our vicious circle of swarm formation and its consequences. Further, we may recognize in the early stages of the vicious circle the "incipient swarming" of many authors, and in the vicious circle as a whole the process referred to simply as "swarm formation." There are, of course, minor inaccuracies in these correlations, due to the fact that a diagram cannot represent all the interrelations of the processes, nor the considerable degree of overlapping in time between different processes. Thus the color change in the hoppers commences while the process of aggregation is operating, although it probably does not receive its major impetus until the marked increase in activity associated with the vicious circle of swarm formation.

It may be noted that the term "gregarization," as used by all the authors cited, includes the gradual transformation of behavior and of all the other phase characters. It is thus synonymous with "transformation into the phase *gregaria*," although in "gregarization" the major emphasis seems to be placed on behavior, and in "phase transformation" on the secondary characters. The verbal form "gregarize" is a useful term, especially in such expressions as "strongly gregarized" or "weakly gregarized" individuals or populations (cf. Bodenheimer, 1944). The term "degregarization" might well be used for the reverse of gregarization, and is to be preferred to Bodenheimer's term "degregation."

Turning now to the mechanism of phase transformation in the narrower sense of the mechanism whereby the physical and physiological characters are modified, we find almost universal agreement that the changes depend upon the level of activity and excitability, usually operating through their effect upon general metabolic processes. This view is exemplified by the "locustine" theory of Faure (1932) [p. 378], and may prove to be applicable to the color changes, the physiological changes, and perhaps the changes in absolute size and sexual dimorphism. In the case of the pronotum-head ratios, Uvarov and Thomas (1941) have brought forward evidence which indicates that the changes are probably due to direct mechanical effects of the frequency of muscular contraction upon the conformation of the skeleton during development [p. 381]. A similar explanation may hold for the E/F ratio, muscular contraction being assumed to shorten the femur.

The supposed role of activity in all these effects is supported by the nature of the circumstances under which isolated individuals may develop the characteristics of the phase *gregaria* or *transiens*. Apart from the direct production of increased activity in isolated hoppers by means of mechanical contrivances [p. 380], the results of which have been criticized by Chauvin [p. 380], we know that both in the field and in the laboratory these characteristics tend to arise under conditions of high temperature, low humidity, and food scarcity [p. 380]. High temperature and food scarcity are known to stimulate activity, and the former also has a direct effect on the basal metabolism. The apparent effect of low humidity may be due to its usual correlation in the field with high temperature and food scarcity. The effect of CO_2 in producing the *gregaria* coloration in isolated hoppers [p. 370] may be due, as hinted by Husain and Mathur (1936b), to an interference with the respiratory mechanism by means of which waste metabolites are converted into CO_2, thus leading to the same increase in their concentration that would result from their excess *production* by active crowds. Alternatively, the increase in the rate of the ventilating movements which occurs as the CO_2 tension is raised may possibly be equivalent to locomotor activity from the point of view of producing the phase *gregaria* pattern.

It must be admitted that not all those workers who have produced ph. *gregaria* characters by these various means have reported an increase of activity among the isolated insects [p. 374], and also that such characters may arise in the apparent absence of conditions liable either to stimulate activity or to produce the same metabolic effects as activity [pp. 375, 376]. However, we know too little, both about the estimation of activity and about the possibilities of reproducing its effects by other means, to evaluate the significance of these observations. Chauvin's conclusion [pp. 380, 381] that the *gregaria* coloration in nymphs and adults is the result of a nervous- and/or endocrine-controlled reaction to sensory impressions, and has nothing to do with activity, is in complete opposition to the prevailing view, and until further experiments are carried out to test this theory, the fundamental mechanism of phase transformation must be in doubt.

Phase Transformation and Outbreaks

We have seen in the historical section of this paper how the Phase Theory was, from the very beginning, linked with the phenomenon of the development of locust outbreaks, and with their periodicity, and how the transformation of the phases was regarded as fundamental to both phenomena. This crucial role of phase transformation was ascribed to its effect upon reproductive potential and migration, and to the supposed irreversibility of the outbreak process once phase transformation had commenced [pp. 364, 365, 365, 381, 381]. We have seen, also, that a few dissenting voices were raised as early as 1930 [p. 382], and that the work of a number of other investigators has to a considerable extent undermined this part of the theory, without, however, leading to open criticism of it [pp. 382, 383]. In particular, it has been shown that an increase of reproductive potential has not been demonstrated in most locusts; that extensive migrations can take place without phase transformation, i.e., in the phase *solitaria;* that transformation into typical phase *gregaria* does not always lead to outbreaks; and that phase transformation can be arrested and reversed by the operation of a number of entirely normal factors of the environment.

Uvarov (1928) has pointed out that "periodicity" is not the right term to use with reference to locust outbreaks, since there is usually no regularity about their incidence. Nevertheless the term has continued to be used, and will be retained here.

A very important circumstance that has seldom been brought into relation with the question we are now considering is the existence of outbreaks of grasshoppers, i.e., of Acrididae in which a gregarious phase is absent and migration very restricted. These outbreaks are "periodic," as in locusts, although not accompanied by sudden mass invasions. They occur from time to time over very large areas in many parts of the world. In the typical grasshopper, migration is quite insignificant, and the area within which an economic infestation occurs is identical with that in which the population increase has taken place. In other grasshoppers, such as some American and Siberian species, and the Australian *Austroicetes cruciata* (Sauss.) (Key, 1938; Andrewartha, Davidson, and Swan, 1938), a limited capacity for migration results in a narrow fringe of "invasion area" around the much larger area in which multiplication has occurred and most of the damage has been occasioned. From this condition there is a clear transition, through such species as *Calliptamus italicus*, to locusts such as *Locustana pardalina* (see Faure, 1937) and *Chortoicetes terminifera* (Key, 1945) in which areas in which multiplication has occurred (the outbreak areas) are much smaller than the invasion area, but are nevertheless of very considerable size themselves, so that damage inflicted within their confines would be a serious matter quite apart from the migrations. In *Schistocerca gregaria*, the numerous small outbreak areas are collectively very much smaller in relation to the invasion area than in the last two species, but many of them are under crops, so that significant damage can be caused within them. Finally, in *Locusta migratoria migratorioides* and *Nomadacris septemfasciata* we have two locusts in which the outbreak areas are very few and very small, and the whole of the significant economic loss is suffered in the invasion area.

As we follow up the series from the typical grasshopper to a locust such as *Locusta*, we find that migration, from being an insignificant factor in the outbreak, becomes the crucial factor. However, we must not lose sight of the fact that the *abundance* of a pest is the distinguishing feature of an outbreak, and that migration becomes of significance only if it involves immense numbers of individuals. The most fundamental condition of an outbreak is thus an increase in numbers, and there is no evidence that the factors promoting an increase in the population of locusts in an outbreak area are different in their general character from those that lead to outbreaks of grasshoppers. Admittedly we know that in *Dociostaurus maroccanus* and *Locustana pardalina* phase transformation involves an increase in fecundity, but, on the one hand, this does not normally occur in locusts, and, on the other, no studies have been undertaken to determine whether a similar increase in fecundity may not occur in some grasshoppers at high population densities.

Thus it would seem that if any unique role is to be accorded to phase transformation in bringing about outbreaks of locusts such as *Locusta* and *Nomadacris*, it must be in relation to migration, and the demonstration that extensive migration of the phase *solitaria* can occur in several locusts is a severe blow to the theory of the relation of phases to outbreaks. It would appear that the difference in the character of the outbreaks of locusts and of grasshoppers consists primarily in the fact that the former have a capacity to migrate, rather than that they possess a gregarious phase. When the population in the outbreak areas consists of sparse *solitaria*, any migration that takes place would not be noticed; when it consists of very numerous *gregaria* it is noticed, both because of the very large numbers involved, and because their gregariousness makes the unit of observation the swarm rather than the individual (see also Williams, 1947, p. 176). Furthermore, migration at densities intermediate between very sparse and very dense must often be forestalled by the process of phase transformation, which concentrates such populations before migration commences. Thus the false impression is gained that only phase *gregaria* migrates. On the other hand, although careful comparative studies of the migration of the phases have not been made, there is evidence that transformation into the phase *gregaria* has a quantitative effect upon migration which is probably important in connection with outbreaks, at least of some species. Thus it probably makes migration more general among the locusts of an outbreak area. It also induces migration before the available food in the outbreak area is consumed, and maintains the migratory urge irrespective of the food supply in the invasion area. The evidence suggests that the phase *solitaria* migrates mainly, perhaps only, when conditions have become unfavorable.

Thus phase transformation may be regarded as a contributing factor in the production of outbreaks, at any rate of species in which migration is a condition for economic damage, but it cannot be regarded as a fundamental prerequisite, "the key to the whole problem." Furthermore, even this limited role is a function of the change in migratory behavior and fecundity only, and we have seen that the physical phase characters are not only poorly correlated with the behavior characters, but make little or no contribution to their transformation. Thus the greater the emphasis placed upon the physical characters in the concept of "phase," the less justification is there for regarding phase transformation as having a significance in the development of outbreaks.

There is even less reason to associate phase transformation of locusts with the *periodicity* of their outbreaks than with the origin of them. Even if we were to concede that the appearance of locusts in an invasion area were entirely the consequence of phase transformation, we must recognize that that transformation is itself the consequence of conditions in the outbreak areas which determine the density of the locust population there. Kennedy (1939) has concluded that the "decisive factor in an outbreak year" is multiplication ("virtual concentration") and the factors permitting it, and the same view has been expressed by Maxwell-Darling (1936) and Zolotarevsky and Murat (1938). Thus, as regards periodicity of outbreaks, locusts are in no different position from grasshoppers and many other insect pests: the periodicity is due to the periodic occurrence of particular environmental conditions.

The undue emphasis upon phase transformation as a cause of outbreaks and their periodicity has distracted attention from the really basic causes of these phenomena, namely the multiplication of the insects as conditioned by climatic and various topographical features of the environment. Thus the outbreak area has been defined, not as a region in which conditions permit such a high degree of multiplication that swarms are formed and emigration takes place, but as a region in which phase transformation takes place (in the outbreak centres) [p. 381]. In the study of outbreak areas the emphasis has been placed upon the transformations of behavior that occur there, rather than upon the characteristics that promote multiplication. Indeed Uvarov (1937), from purely theoretical considerations connected with the environmental conditions for phase transformation, has argued (p. 6) that "... we can now safely dispose of the old conception that the outbreaks commence in the areas and seasons with the most favorable conditions for the species," and that the outbreak areas are actually located on the fringes of the continuous specific area, where the locust leads "a somewhat precarious existence." The same view has been expressed by Zolotarevsky (1946, p. 103).

It is difficult to see how such a view can be sustained, in view of the wealth of observations to the contrary. The outbreak areas are preeminently areas in which locusts can always be found, frequently in numbers very much above those outside. The work of Faure (1932) has made this sufficiently clear for *Locustana pardalina*, but the same observation has been made by many authors on several different species. Shortly before the commencement of an outbreak the locust population of an outbreak area is at a very high level. It is not just a matter of dense but widely-scattered local concentrations. At this stage concentration is only beginning, and a moderately dense population is spread over extensive areas (see Smit, 1939). Wherever the boundary of the outbreak area is clearly marked, for example by a soil change, the difference in the population inside and outside the area is very noticeable (see Key, 1945). It is obvious, of course, that a very low level of population is reached in an outbreak area after the emigration of swarms. It is therefore a remarkable demonstration of the special favorability of outbreak areas for multiplication that within a comparatively few years this population should be able to reach the critical density for swarm-formation once more, whereas elsewhere it remains at a comparatively low level.

Key (1945) has proved conclusively that the outbreak areas of *Chortoicetes terminifera* are located in the climatically most favorable portion of its distribution area. Within this climatic region, the limits of the outbreak areas are determined by characters of the soil and vegetation, and these, too, have been shown to be particularly favorable to the survival and multiplication of the locust (Key, 1945; Clark, 1947a).

At the risk of appearing to digress too far from the main subject under discussion, it may be of interest to consider in what way the general characteristics of locust outbreak areas could favor survival and multiplication of the insects, and why this crucial role of the outbreak areas has remained unrecognized, or has been denied, in the past.

It has, of course, been recognized that multiplication must precede phase transformation in the outbreak areas, but the general view has been that the role of these areas is to promote concentration, and that they are no more favorable to multiplication than many other parts of the permanent habitat.

Perhaps the most universal ecological characteristic of outbreak areas is a marked "patchiness" of the environment, and particularly of the herbaceous vegetation. Such a patchiness is commonly found in the ecotones between distinct major plant communities, but may also occur elsewhere. It produces a mosaic of habitats, the extremes of which may be very different. Now probably all locusts show distinct habitat preferences at different stages of their development, the preferred habitats for the eggs and for the adults, in particular, being commonly widely divergent. If we assume that these preferences correspond to differences in the favorableness of the habitats for survival and optimal functioning of each stage, it follows that a region in which the major preferred habitats are distributed in a patchwork, on such a scale that both habitats are within the normal dispersal range of the locusts, will be more favorable to survival and optimal functioning than any uniform environment. It has been observed that locusts of several species do, in fact, utilize the patchiness of their outbreak areas in their various activities (cf. Kennedy, 1939, Smit, 1939, Bodenheimer, 1944, etc.).

Apart from providing optimal habitats for different life-cycle stages, a patchy environment of the right type has a buffering effect on gross climatic variation. In such an environment a mobile insect can find optimal, or at least tolerable, microclimates under the most extreme general climatic conditions, and its survival and normal functioning are thereby promoted. Further, in a patchy environment one extreme habitat is connected with the other extreme by a gradient of intermediate conditions. Weather and seasonal factors may alter the characteristics of an area that was formerly optimal for a given stage of the life-cycle, but at the same time these factors would be likely to reproduce the optimal habitat a little further along the gradient between the two extremes, so that in effect all that has happened is that the optimal habitat has shifted its location.

These advantages of a patchy environment from the point of view of keeping locusts alive under unfavorable conditions, and promoting their rapid increase under more favorable ones, seem evident enough. However, precisely the same patchiness is conducive, largely for the same reasons, to periodic concentration and, on the smaller scale, aggregation of locusts, and thus to phase transformation (cf. Uvarov, 1937, and others). The predominant preoccupation with phase transformation as the crucial process in the development of outbreaks, and as the criterion of outbreak areas, has had the result that the concentrating function of the patchy environment was regarded as sufficient explanation of its close association with outbreak areas, and its more fundamental function in relation to multiplication was overlooked.

Another very general characteristic of outbreak areas is climatic instability. This, also, has been evaluated almost entirely in terms of concentration, as promoting wide fluctuation in the areas of favorable habitats (cf. Uvarov, 1937), and synchronizing the life-cycle. However, this instability must have another consequence which may well be of much greater importance in locust epidemiology. In a favorable but stable natural environment an insect population tends to approach a stable equilibrium with its predators and parasites, and this precludes excessive multiplication of any one member of the system. In an unstable environment, on the other hand, the host can temporarily escape from the restrictive influence of its biotic controls and build up to very high numbers. When this is accompanied by migration, the food supply can recover, and the stage is set for a repetition of the process with the next swing of the climatic cycle.

The arid nature of the outbreak areas of many locusts has perhaps contributed to the belief that they must be relatively unfavorable. Apart from the fact that aridity is usually associated with the favorable factor of climatic instability, this view also ignores the deleterious effect of over-moist conditions upon most Acrididae. This effect seems to operate mainly through bacterial and fungal diseases, and is so powerful as to restrict certain species to regions with an annual rainfall of less than 10 in., when there appears to be no other reason why they should not occupy better country in which their food supply would be assured. The fact that a population increase of such species follows good rains in the arid regions is not necessarily relevant to the question, because there is a very great difference ecologically between occasional heavy rain in an arid region and continuous humid conditions of the same degree elsewhere.

For an elaboration of the point of view of the preceding paragraphs in relation to *Chortoicetes terminifera* and *Austroicetes cruciata*, the reader is referred to the work of Key (1945) and Clark (1947a, 1947b).

The conclusion that phase transformation, even in its purely behavioral aspects, is a subsidiary factor in locust epidemiology calls for a restriction in the use of phase terminology in this field, and such restriction is the more necessary the greater the emphasis placed upon physical characters in the definition of phase. In epidemiology the expression "phase transformation" can almost always be replaced with advantage by the expression "swarm formation." The term "swarm" includes the ideas of large numbers, gregariousness, and migratory capacity, and "swarm formation" thus describes very adequately the crucial process from the point of view of the development of a locust outbreak. It further avoids all the ambiguities of the phase terminology. From the point of view of epidemiology it is almost entirely immaterial whether the individuals composing a locust swarm are typical phase *gregaria*, or, as in the swarm described by Kennedy (1939), typical phase *solitaria*. The Fourth International Locust Conference placed the emphasis in the wrong place when it resolved [p. 370] that the phase *solitaria* is "relatively harmless," and the phase *gregaria* "dangerous": it is only numbers and migratory capacity that are dangerous.

Australian workers on locust epidemiology have avoided the phase terminology altogether, and have employed such expressions as "swarm formation," "non-swarming population," etc., without any loss of meaning and without undue circumlocution. Faure (1935, pp. 27–28) has also described the origin of an outbreak quite successfully without reference to phase transformation. The author has elsewhere (Key, 1938, 1945) proposed definitions of "distribution area," "infestation area" (which includes "invasion area"), and "outbreak centre," in which the usual phase terminology of these definitions is replaced. The whole range of distributional terms used in locust ecology may be defined along these lines as follows:

Total distribution area: The region in which the species has at any time been found.

Area of permanent occupation: The region in which the species is always to be found (i.e., if searched for with sufficient thoroughness in the right habitats and at the right time of year).

Infestation area: The region in which swarms of the species have at any time been found.

Outbreak center: An area the ecological conditions of which sometimes lead to swarm-formation, and all parts of which contribute to this effect.

Outbreak area: An area containing numerous outbreak centers interspersed with non-outbreak-center country, and usually separated from the surrounding country by relatively sharp discontinuities in frequency of outbreak centers and in topographical features (including soil and vegetation, as well as physiography).

Outbreak region: The whole region in which the outbreak areas are situated.

Invasion area: The region which has at any time been invaded by swarms, but in which swarm-formation cannot occur (i.e., the infestation area less the outbreak areas).

Swarm-formation itself may be defined as "the formation of swarms from a non-swarming population."

What Does the Phase Theory State?

We may now pass from the component concepts and terminology of the Phase Theory to the Phase Theory itself. It is remarkable that the literature should contain no clear and simple statement of what the Phase Theory actually is. In spite of this lack, it is possible to infer, particularly from Uvarov's own earliest publications on the subject, what the basic propositions are. Unfortunately, the lack of clarity at the beginning has opened the door to varied interpretations and extensions of the content of the theory, so that it is by no means certain that general agreement can now be obtained on its scope.

It has already been stated [p. 364] that the theory as originally presented could be reduced to three propositions. Of these, only two are really fundamental, namely:

1. In certain locusts there are two distinct forms of infraspecific status—the "phases"—which are connected by transitional forms, and are mutually transformable in successive generations; and
2. The transformation of the phases is responsible for the periodicity of locust outbreaks.

It has been shown above that the second of these propositions cannot be upheld: that, in fact, phase transformation is at most a contributing factor in locust outbreaks, or one responsible for certain features of the outbreaks only. This leaves us with the first proposition, and we have now to consider what expansion of that proposition is necessary in the light of our increased knowledge.

In the first place, we have to decide whether we can agree with Zolotarevsky (1946, p. 43) in admitting to the field of the Phase Theory variations due to the interaction of individuals, if no physical differences between the two types can be discerned [p. 378]. This involves the question, already raised in this paper [p. 384], whether the Phase Theory can have any specific content at all if it does not concern itself primarily with physical differences. All the other phenomena of phases, as Zolotarevsky (1946) has rightly stated [p. 378], and Klingstedt (1939) and Chauvin (1941) also suggested, have been well known for many years in a wide range of animals. Migration, for example, has been studied in some detail in birds, fishes, mammals, and insects. It is commonly associated with temporary gregariousness, sexual maturation, or both. It involves extensive mutual interaction of individuals, increase of their activity, and alteration of their usual behavior patterns. Parallel with these changes go fundamental physiological changes. Incidentally, these migrations may lead to what one might call "outbreaks" of the species concerned in the region invaded. Where these changes have not been found to involve parallel "physical" changes, or at least significant changes in the type of physical character used in the taxonomy of the group, they could be, and were, studied perfectly satisfactorily without the aid of any Phase Theory. It was only when a species was encountered in which the individuals composing gregarious populations were found to be so unlike those composing non-gregarious populations as to be regarded as a distinct species that scientific advance was blocked, and the stage was set for a theory that would reintegrate the species as an object of study, by declaring that the two forms are conspecific and mutually transformable. In investigating the epidemiology of locusts, workers who had been baffled by the apparently complete disappearance of the species after one outbreak, and its reappearance "from nowhere" at the commencement of the next, could then apply the appropriate ecological methods of study to the species over its whole range of abundance, with very gratifying results. It appears incontrovertible that, were it not for the fact of physical (morphological and color) differences between gregarious and non-gregarious populations of locusts, there would have been no Phase Theory and no need for one.

Many prominent workers on phases appear to have adopted the view that the fields of study (in ecology, epidemiology, and social behavior) that were thus made possible by the major contribution of the Phase Theory in reintegrating the species should be, so to speak, taken under the banner of the Phase Theory itself, becoming extensions and logical consequences of it. It is probably along some such lines as these that the mistaken emphasis came to be placed on phase transformation in connection with the periodicity of outbreaks. As a result the concept of the Phase Theory has steadily widened, until to many authors it calls to mind the periodicity of outbreaks, the recognition of outbreak areas, and the mechanism of the development of gregarious behavior, rather than physical differences. Zolotarevsky's references (1946, p. 108) to the mysterious "nature" of the phenomenon of phases, as distinct from their "manifestations," strike an almost metaphysical note; for if the Phase Theory is concerned with anything at all, it is concerned precisely with "manifestations." We must, then, retain the concept of physical differentiation as the core of the Phase Theory.

The Phase Theory as originally promulgated referred only to locusts. Subsequently, phases were shown to exist in other Orthoptera [pp. 368, 369, 377] and in certain Lepidoptera [pp. 376, 377, 378]. It seems very probable that at least rudimentary phase differences may be found in other groups of insects, and in animals other than insects. The theory should be stated in sufficiently general terms to cover these possibilities. Further, the original theory specified *two* distinct forms, although these were connected by a complete series of intergrades. In discussing the concept "phase," the view has been taken that this term is applicable to all the innumerable forms of the series [pp. 383, 384], so that the number of possible phases becomes infinite.

Finally, it seems essential to include in any statement of the Phase Theory a definition of the particular *kind* of variation with which the theory deals. As we have seen [pp. 383, 383], the phases were originally regarded as types of individual associated with different degrees of *gregariousness*. As investigations continued, it was found that both the physical characters of the types and their degree of gregariousness are determined by the *population density*, and that population density exerts its influence through *mutual stimulation*. *Activity* has long been regarded as the usual means whereby mutual stimulation determines phase, although this has been denied by Chauvin (1941). We cannot be content with Zolotarevsky's "interaction" as the determining factor (Zolotarevsky, 1946), because physical changes that have nothing to do with phases can result from interaction (e.g., changes in size due to competition for food, or the controlled production of castes in social insects). In view of the occurrence of physical changes, in all respects analogous to phase changes, in insects that vary strongly in population density but do not show actual gregariousness (Rubtzov, 1935; Chopard, 1935; etc.), and also in sparse, non-gregarious populations of locusts of different density (du Plessis, 1939; etc.), it appears unwise to restrict the Phase Theory to physical types associated with gregariousness. At the same time, we can hardly admit as a phase any physical type owing its character to a particular level of *activity*, quite apart from the doubts on the significance of activity introduced by Chauvin (1941). The nature of the variation we are concerned with seems to be fully specified, however, if we say that it normally depends upon *the degree of mutual stimulation in populations of different density*. The qualification "normally" is necessitated by the evidence that more or less typical phase changes can be produced, at least in the laboratory, in isolated individuals.

CONCLUSIONS

In the light of the considerations brought forward in the above analysis, the following conclusions may be drawn:

1. Uvarov's Phase Theory, which has never been succinctly formulated, may be stated as follows:

> In certain animals, different degrees of mutual stimulation between the individuals composing populations of different densities lead to the appearance of distinct physical types—the "phases"—which typically differ also in their physiology and behavior. The phases may, within one or several generations, be transformed one into the other by an alteration in the degree of mutual stimulation.

In this statement the accent is upon physical differentiation (without which the theory could have no specific content), in relation to population density rather than gregariousness. No limit is placed upon the number of phases that may be recognized, and the scope of the theory is widened to include any animal.

2. Phase transformation must be regarded as a secondary concomitant in the development of locust outbreaks, or at most a minor contributing factor in which only certain aspects of the transformation are significant. The development of outbreaks and their periodicity are not, strictly speaking, the concern of the Phase Theory at all.

3. A phase is a type of individual whose distinctive physical and other characters are of the kind determined by the amount of mutual stimulation experienced in a population of a particular density.

> [It is, of course, a simpler matter to define "phase variation" than "phase." The former is a more abstract concept, and as such can be isolated in thought from other kinds of variation to which an animal may be subject. "Phase," while still an abstraction, refers to the characters of concrete individuals in which the effects of phase variation cannot be completely separated from those of other sources of variation. Thus phase variation is superimposed upon variation due to independent environmental and genetic factors affecting the same characters, though usually to a much smaller degree. Further, the degree of mutual stimulation, and hence the extent of phase variation, may itself be modified by environmental and internal factors acting independently of population density.]

4. In a more specific sense, a phase is one of three such types designated respectively *solitaria*, *transiens*, and *gregaria*. The phase *solitaria* is the type characteristic of populations showing no trace of gregariousness, and whose immediate antecedents also showed no gregariousness. The phase *gregaria* is best defined as the type characteristic of swarms, i.e., populations showing clearly-marked gregariousness, and behaving substantially as collective units. The phase *transiens* is the type characteristic of populations with a history of gregariousness intermediate between that of *solitaria* and *gregaria*.

5. Non-gregarious grasshoppers, and other non-gregarious animals, cannot, therefore, possess a phase *gregaria*, even when they occur in dense populations; but they may show phase variation. If they show slight gregariousness, without forming definite swarms, they may be conceded a phase *transiens*.

6. The categories "*congregans*" and "*dissocians*" are not phases, because they are not defined on the basis of a difference in mutual stimulation, population density, or gregariousness, and do not necessarily display distinctive physical or other characters. If one wishes to indicate the direction of phase change, such terms as "gregarizing individuals" and "degregarizing individuals" might be used, although it is necessary to remember that there is never any guarantee that an observed trend in phase transformation will be maintained in the same direction for any length of time.

7. "Phase" is essentially a characteristic of individuals. However, a population may be said to have a phase, in the specific sense of ph. *solitaria*, *transiens*, or *gregaria*, if it is entirely homogeneous for the phase in question.

8. A measure of what may be called the "phase status" of a population may be obtained in the form of means and standard deviations for suitable phase characters of the component individuals, or by a frequency measure. In the case of a morphometric ratio, any such mean must be the mean of the individual ratios, and not the ratio of the totals of the absolute measurements, as recommended by successive International Locust Conferences. The phase status of a popu-

lation may also be estimated by the sexual dimorphism ratio and other measures which, while depending upon individual phase characters, are not themselves measurable in the individual.

9. The degree of correlation between different phase characters, both physical and biological, is low, so that the indications of phase given by different characters may be markedly conflicting. This makes it impossible, for example, to draw reliable inferences as to behavior from the physical characters, and has led to general confusion as to what is implied, in any particular instance, by the phase terminology.

10. As a consequence, we are faced with the alternatives of (a) reconciling ourselves to using the phase categories in a vague way to indicate types with ill-defined constellations of characters, or (b) defining the phases of each species in a rigid, if somewhat arbitrary manner, by means of ranges of values of the best morphometric character for differentiating the phases in that particular species. This choice is by no means an easy one, but alternative (b) is to be preferred, since it does provide a completely objective basis for defining the phases by using that physical character, open to quantitative estimation, which is the most intimately associated with the cause of phase differences. Adopting this course, it is clear that only adult insects, with the parts to be measured undamaged, can be classified into phases. Nymphs and damaged adults cannot be identified with certainty. While this is unfortunate, the situation is no different from that in which material of all stages is placed under alternative (a), where, since the phases themselves are not rigidly defined, no specimen or series can be certainly identified.

[Since the whole field of locust ecology and epidemiology can be studied without reference to phases, the phase terminology could no doubt be dispensed with altogether if we had only the requirements of this field to consider. But the phases have a taxonomic, as well as a biological significance. Taxonomy is concerned with the full range of physical variation of a species, and well-marked infraspecific forms need to be differentiated and named.]

11. In determining the ranges of the best morphometric character for use in defining each phase, the following procedure is desirable: Numerous large series of specimens should be obtained for a number of different localities and seasons, and representing the full range of gregariousness from sparse non-swarming populations with non-swarming antecedents up to the largest and densest swarms with swarming antecedents. These series should be grouped, purely on their degree and history of gregariousness, as "non-swarming with non-swarming antecedents," "swarms," and "intermediate." Series means, group means, and the interseries variance within each group should be calculated for each major morphometric character. The best indicator of phase may then be selected as that character which gives the most significant differences between the groups. This best indicator should be a phase character proper, and not, for example, the sexual dimorphism ratio, which cannot be applied to individual insects.

Using the series means of the best indicator, the range of means corresponding to each of the three categories of gregariousness should be determined. Overlap will be found, not only between the ranges for adjacent categories in the gregariousness sequence, but sometimes also between the range for non-swarming populations with non-swarming antecedents, and the range for swarms. Arbitrary limiting values should then be selected so as to give three contiguous, non-overlapping ranges, in which a maximum proportion of the series means will fall into the phase to be expected from the degree and history of gregariousness of the series. The phases in the particular species concerned are then rigidly defined by these ranges of the best indicator. The phase status of any series can then be determined as *solitaria*, *transiens*, or *gregaria* on the basis of its mean for the selected character, and any individual can be assigned to its phase on the basis of its individual value for the character.

12. It remains desirable to have some means for indicating the general phase affinities of nymphs, etc., which cannot be definitely classified under the system proposed. Sometimes it may be best simply to describe in a few words what the significant characters of such individuals are. Thus one might speak of "*black* first-instar hoppers." Something more than this is required to indicate the general ensemble of characters, and the terms "solitarioid," "gregarioid," and "transientoid" might be used for that purpose, not italicized, not accompanied by the word "phase," and necessarily of somewhat uncertain connotation. For example, one might say: "The swarm of yellow, gregarioid adults, of which no specimens were taken, produced typically gregarioid hopper progeny. Stragglers from this band became transientoid by the final instar, and

gave rise to ph. *transiens* adults." The same terminology could be used for species in which phase studies are not sufficiently advanced for rigid definition of the phases to have been possible.

13. The "outbreak process" is more readily analyzable into operative processes than into stages in time. The essential process is the "vicious circle of swarm formation," which is a purely behavior phenomenon. The classical physical phase differences arise as secondary consequences of the outbreak process, and play no important part in promoting either further phase transformation or further development of the outbreak process. They are, at most, pointers to the stage that has been reached in the outbreak process, and somewhat unreliable pointers at that.

14. The definition of the phases on the basis of physical characters, coupled with the uncertain correlation between the physical characters and behavior, calls for an independent classification of individuals and populations on a behavior basis. The unambiguous terms "swarming" and "non-swarming" are proposed for this purpose, the latter being synonymous with "solitary-living." The dual classification then permits such combinations as "swarms of ph. *solitaria*," "non-swarming gregarioid hoppers," etc.

15. The fundamental cause of outbreaks of locusts is multiplication, and the "irregular periodicity" of outbreaks is primarily due to changes in the population level of the outbreak areas, whose ecological characteristcs are particularly well adapted to permit survival under unfavorable conditions and rapid multiplication under favorable conditions. Several features of the outbreak areas that make them favorable for locust multiplication also promote concentration, and thus set in train the development of gregariousness and transformation into the ph. *gregaria*. In the course of these changes migration is probably stimulated; certainly it is made immediately obvious, and practically significant, on account of the gregariousness of the insects and their numbers.

16. The factors of abundance, gregariousness, and migratory capacity are all reflected in the word "swarm," and the essential process that goes on in the outbreak areas is best described as "swarm formation." It is the change in the abundance and behavior of locusts in the outbreak areas that produces an outbreak, rather than phase transformation. "Outbreak area," "outbreak center," and other distributional terms used in locust epidemiology are therefore best defined in terms of the contrast between swarms and non-swarming populations, rather than the contrast between the phases.

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NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will occasionally appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to H. B. Glass, Associate Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

THE SCIENCE OF ECOLOGY TODAY

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A review of PRINCIPLES OF ANIMAL ECOLOGY. *By W. C. Allee, Alfred E. Emerson, Orlando Park, Thomas Park and Karl P. Schmidt. W. B. Saunders Co., Philadelphia and London.* $14.00. xii + 837 pp.; ill. 1949.

It is no longer a common practice among biologists, as it used to be up to about a generation ago, to write books summarizing the state of knowledge in their branch of science. This is probably because, in our day of intense research activity in many fields, new data accrue so rapidly, chiefly in the form of short journal articles, that a summary becomes antiquated often before the printer's ink is dry. Yet such books are invaluable to advanced students and to beginning research workers who need to find out what has and what has not been accomplished by their predecessors in their chosen field; textbooks do not serve this purpose, except incidentally. Such books are also a boon to workers in related disciplines, who otherwise find it difficult to keep abreast of developments outside their own specialty. It is, therefore, extremely gratifying that the five most eminent representatives of the Chicago school of ecology have written "a study of the underlying principles [of animal ecology] together with a sampling of the evidence on which they are based." The "sampling" is, however, so generous, (the bibliography alone occupying 71 pages), and the presentation so concise that the book approaches the status of a full-fledged encyclopedic treatise on modern animal ecology.

It may well be that ecology has needed just such a treatise more than any other biological discipline, because it covers an exceptionally broad field with somewhat indefinite boundaries. The authors define ecology as "the science of the interrelation between living organisms and their environment, including both the physical and the biotic environments, and emphasizing interspecies as well as intraspecies relations." Ecology impinges upon almost every other biological discipline, and upon several physical sciences as well. The book under review discusses topics as diverse as geological climates, oceanic currents, atmospheric gases, soil chemistry, mutualism and parasitism, human demography, interspecific competition, the organization of insect societies, marine sediments, environmentally induced mutations, hybrid sterility, rudimentation, sexual selection, etc. This does not, however, mean that ecology has become a sort of holding company superimposed upon other disciplines; it means that ecology is a discipline in which synthesis plays a greater role than it does in many other fields, and which may accordingly be instrumental in tying together otherwise scarcely related specialties. It is therefore important to show, as this book does so admirably, how the almost bewilderingly diversified subject matter fits together with a core of clearly defined principles. And it must be noted in this connection that although the book under review claims to cover only animal ecology, the authors have, as they were well-nigh forced to, drawn freely upon plant material. Nevertheless, this reviewer cannot restrain himself from expressing a regret that botanical ecologists are not included among the authors so that the word "animal" might have been deleted from the title.

The book opens with an introduction containing important definitions and statements of principles and a concise history of ecology. This was written by W. C. Allee, Thomas Park, and K. P. Schmidt. There follows a section on the Analysis of the Environment, written mainly by W. C. Allee, which is a masterpiece of lucid presentation and of integration of most diversified material. Sections on Populations (by Thomas Park) and on The Community (by Orlando Park) form the central portion of the book, which concludes with a section on Ecology and Evolution by A. E. Emerson.

Park defines *population* as "any single or mixed species association in the laboratory or in nature that presents a closely interacting system which can be studied and expressed with some quantitative rigor." This is, of course, a much broader concept than the (Mendelian) population of geneticists, which is a group of sexually reproducing and cross-fertilizing individuals which possess a common gene pool. Ecological population studies include the analysis of natality, mortality, age distribution, rates of growth, equilibria, oscillations, and interspecies competition in populations. The *major community* is defined (by O. Park) as "a natural assemblage of organisms which, together with its habitat, has reached a survival level such that it is relatively independent of adjacent assemblages of equal rank; to this extent, given radiant energy, it is self-sustaining." In my own opinion, this very cogent definition represents a goal to be aimed at in community studies; up to now, such studies have been in the main descriptive rather than analytic, and have given little information on the survival levels and self-sustaining abilities of the assemblages examined. This should not be construed as a criticism of the definition—definitions may be more useful if they serve to direct further research into proper channels than if they merely summarize the inadequacies of the present knowledge.

The short chapter on Animal Aggregations (by W. C. Allee) is, to me, one of the most thought-provoking in the book. The central idea here is "that natural, unconscious mutualism is one of the basic principles of biology." This generalization is supported by a mass of diversified evidence which shows that the protocooperation and cooperation of organisms of the same and of different species have great survival values. This is, evidently, an important corrective to the naive view that evolution is promoted exclusively by the struggle for existence. The "struggle" involves cooperative as well as disoperative elements, and the former are adaptively more efficient. This idea is extended further by A. E. Emerson in the concluding pages of the book, where the adaptive value of the integration of organisms in communities is visualized as leading to formation of "a biotic system that may appropriately be called an interspecies supraorganism. The incorporation and control of the physical habitat by the interspecies supraorganism produces a unitary ecosystem." The validity of the concept of supraorganism will depend upon the precise meaning put into it; in my opinion, no serious objection should be raised against its use in the book under consideration, but it is a construct which is peculiarly apt to be misused if incompletely understood.

The inclusion in a treatise on ecology of a thorough account of modern theories of evolution connotes a most important development of ecological thought, one in which A. E. Emerson has been a leader. Indeed, it is the evolutionary idea that gives an internal unity to the field of ecology; and ecological investigations contribute basic data for an understanding of the mechanisms of evolution. If the book under review were to accomplish nothing more than to persuade ecologists that the above propositions are true, its important role in the history of ecology would be assured. The manner of presenting evolutionary theories adopted by Emerson resembles, among existing models, that in the well-known book by Julian Huxley. Both presentations are characterized by a profusion of references to the literature, of inestimable value to students of the subject (needless to say, Emerson has used much new literature and many sources not known to Huxley). The viewpoints of Emerson on certain controversial problems happen to differ from my own. Thus, the arguments presented in favor of the possibility of sympatric speciation do not seem convincing, and do not answer the objections against this possibility recently formulated by Ernst Mayr. The inclusion of geographic (spatial) isolation among reproductive isolating mechanisms is hardly defensible, since, as Emerson admits, geographically isolated populations may be genetically identical while reproductively isolated ones are necessarily different; furthermore, the term "reproductive isolation" has been proposed specifically to distinguish between the geographical and other forms of isolation. Failure to distinguish between these categories of isolating mechanisms leads to a lack of clarity in the species concept. Despite these, and some other disagreements, this reviewer can only endorse Emerson's general evolutionary views. It is a most gratifying fact that in our day investigators who start from such diverse fields as ecology, genetics, paleontology, systematics, or comparative and experimental morphology and embryology have arrived at concordant interpretations of the evolutionary process.

In conclusion, I quote the last sentence in the book, which epitomizes its general spirit: "Principles that assert facts in meaningful order have not fulfilled their purpose unless they stimulate further fact finding, further discovery of relationships, further synthesis, and ultimately contribute to the evolution of human wisdom."

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GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

SURVEY OF BIOLOGICAL PROGRESS. *Volume I.*
Edited by George S. Avery, Jr. Academic Press, New York. x + 396 pp.; ill. 1949.

Within recent years growing numbers of harassed investigators in the fields of physiology, biochemistry, or microbiology have turned with gratitude to existing literature surveys presented in the form of annual reviews. These reviews provide a partial solution to the problem of keeping informed in areas of information not strictly on the reader's high priority list for source reference. The addition of the *Survey of Biological Progress* to the ranks of such volumes will be received with interest by a more general audience than has been reached in previous attempts to compile current literature into an assimilable form for the non-specialist. Research workers compelled professionally to assume a myopic view of the scientific scene, together with teachers of the life sciences, will find these eleven review articles with their bibliographies a valuable compendium of reference material. Nevertheless, individuals will see the volume in the light of their own spheres of interest, and the wide range of subject-matter entails a risk that for some persons the "misses" will outnumber the "hits." The average reader may then look into the book for the sake of one or two articles marginal to his areas of knowledge, though a study of all will provide a beneficial antidote to overspecialization, and thereby fulfill an avowed aim of George S. Avery, the editor-in-chief, and his distinguished editorial and advisory staff.

Three papers are concerned with experimental botany. K. C. Hamner has described the role of environment in modifying the vitamin concentrations of edible plants. Techniques and points of emphasis in the cultivation and production of disease resistant plants are covered in another chapter, by W. A. Frazier. The influence of growth hormones on normal plants and the contribution of these hormones to cellular proliferation in tissue cultures, regenerative tissue, and plant tumors is well reviewed by Philip R. White, an authority whose significant contributions to the subject are widely known. Discussions of cellular adaptation and habituation of tissues on defined medium are presented without any reference to a possible contribution of genetic variability to the adaptive process, a subject of paramount interest to workers in related fields.

Another contributor, L. M. Black, departs periodically from his description of plant viruses to give salient similarities or differences in the virus tumors of the frog, fowl leucosis, Rous sarcoma, and mammary mouse cancer; and fibroma, myxoma, and infectious warts of the rabbit. Students of psychosomatic medicine claim to have shown the subsidiary importance of psychic factors in the etiology of infectious warts in humans. Let reader and rabbit rejoice that this added intangible is not yet fair game for Black and his colleagues.

A brief chapter by G. E. Hutchinson and E. S. Deevey, Jr. surveys current progress in ecology. In another section R. K. Burns has discussed critically the influence of hormones in sex differentiation. The development of successful methods for the castration of mammalian embryos in utero has given new evidence of the significance of the embryonic gonad in the establishment of sex patterns. In spite of paradoxes, some orderly relationships prevail. Response of the embryo to specific dietary deficiencies, and the more general problem of nutrition as it affects various phases of reproduction is the subject of an analysis by K. F. Mason. Martin Kamen fulfills his now traditional role as the reviewer of tracer methods in biological research. The remarkable advances recently made in the genetics of bacteria and viruses are competently surveyed by Bentley Glass in a discussion of the gene and gene action. In broader scope, his article continues with recent discoveries in chemical and physical mutagenesis, position effect, multiple allelism, and with an integretive treatment of the uncertain but challenging relationship of genes, plasmagenes, viruses, enzymes, and the meristic chemical entities governing many of the most fundamental biological processes. Glass's article forms a logical prelude to some sections of the chapter on growth and development by D. P. Costello. Harriet Creighton's thoughtful treatise on pedagogical problems in biology is of potential value to all teachers. Charles Darwin and other intellectual giants of the 19th century might take exception to her statement that "40 or 50 or even 20 or 30 years ago, a large proportion of what was known could be presented in 1 year." It is rather that our changing interests have left much of the past in obscurity. Modern biology, as represented in this book, is very much a topical and an experimental science.

VERNON BRYSON

PROTOMORPHOLOGY. *The Principles of Cell Auto-Regulation.*
By Royal Lee and William A. Hanson; with an Appended Article on "Cytotoxines" by K. R. Victorov. Lee Foundation for Nutritional Research, Milwaukee. $8.50. xxviii + 365 pp.; ill. 1947.

The central theme of this book seems to be the discussion of the hypothesis that the genes contain an organized assemblage of smaller units, *cytomorphogens*, which are composed of still simpler, quite stable units composed principally of minerals which are the determinants for the specificity of the biological proteins; these basic determinants are the *protomorphogens*. The protomorphogens are discussed as exerting profound effects on the activity of all living cells. Protomorphogens are related in this volume to organizers, to thromboplastin, to cancer, to arthritis, to senescence, to the nausea of pregnancy, to name only a few of the many entities or conditions taken up in the volume. The authors seem to associate "raw" protomorphogen with Burrows' "archusia" and protomorphogen associated with a lipoid "wrapper" with Burrows' "ergusia"; and the book is recommended by the reviewer particularly to readers with a burning interest in certain aspects of the work of Burrows, Carrel, Crile, et alia. Reginald the office boy has murmured that Velikovsky might be mentioned.

Jane Oppenheimer

* * *

Laboratory Directions for General Biology.
By Laurence C. Woodruff and Ruth E. McNair. Wm. C. Brown Co., Dubuque, Ia. $1.35 (paper). iv + 69 pp.; ill. 1947.

This manual contains 15 exercises for a one-semester college course, planned to require a minimum of individual effort from the student. In most cases drawings are provided to be labeled; rarely does the student himself have to make a drawing, and then only of the simplest things. Most of the experiments are performed as demonstrations, the students recording the results and answering a few questions. The Survey of the Living World is given in one exercise that includes both the plant and animal kingdoms in their entirety. The exercise on Genetics consists solely of counting ratios (3:1 and 9:3:3:1) and working a few problems. I have seen Biology Laboratory Manuals and Workbooks for high school courses immeasurably superior to this. It would be uncharitable to mention where the course is taught.

Bentley Glass

* * *

Fundamental Activities in Biology. *A Workbook and Laboratory Manual for Use With Any Textbook.*
By Edwin L. Harer and Chelsey G. Remley. Republic Book Co., New York. 96 cents (paper). x + 302 pp.; ill. 1947.

This workbook and laboratory manual is keyed to be used with any of the widely used high school biology textbooks. It is extraordinarily complete in coverage. Perhaps the major criticism which could be made of it is that the workbook aspect rather completely dominates the laboratory manual. The Appendix contains, among other features, a section on Audio-Visual Aids and another on Special References and Pamphlets that will be of considerable service to the teacher.

Bentley Glass

BIOLOGY: HISTORY AND BIOGRAPHY

Die Entwicklung der makroskopisch-anatomischen Präparierkunst von Galen bis zur Neuzeit.
By A. Faller. S. Karger, Basel. S. fr. 15.-(paper). iv + 115 pp.; ill. 1948.

This excellent monograph describes the instruments used in gross anatomy from antiquity to the present. It narrates the evolution of the techniques of maceration, injection, corrosion, transparency, and macroscopical dyeing. The author does not claim completeness of data, but he comes rather close to it for the 17th century. He has paid relatively little attention to Galen's wealth of techniques. Otherwise he would not give credit to Spieghel for the first corrosion work on the liver. The subject-matter is fascinating to anyone who has ever had any contact with gross anatomical technique (and most biologists have), and the author, who is professor of histology at Fribourg, Switzerland, has handled his subject well. The illustrations are an integral, and not the least valuable part of the book, which is completed by a good chronological table, an index, and a bibliography.

Erwin H. Ackerknecht

* * *

EVOLUTION

Introgressive Hybridization.
By Edgar Anderson. John Wiley & Sons, New York; Chapman & Hall, London. $3.00. x + 109 pp.; ill. 1949.

In the author's words, the object of this book is an "attempt to take the whole problem (of hybridization in evolution) outside the area of argument and opinion and into the zone of measurement and analysis." Partly because of the controversial nature of some of the interpretations which are suggested but more particularly because a fruitful method of attack upon the problem is outlined, the author's conclusions should be stimulating to geneticist, taxonomist, and plant breeder alike. The book is likely to encourage a new interest in the collection of detailed and critical information.

The arguments presented may be summarized briefly as follows: In a hypothetical system of completely independent genes the number of different recombinations resulting from segregation reaches astronomical figures. In actual systems, as a consequence of linkage, the number of recombinations is greatly reduced, and though still large, is probably smaller than has been commonly realized. When differences between characters of two species are determined by many genes, the parental characters will tend to cohere in the generations which result from backcrossing or selfing their hybrid. If the parental species differ considerably in ecological requirements, only a small fraction of the already greatly restricted recombinations will be adapted to the available ecological niches. The successful types will be usually those recombinations which resemble rather closely the parental species. Exceptions to this rule are to be found where man has "hybridized the habitat" (e.g., by cultivation), thus producing new artificial combinations of physiological conditions not normally provided in nature. Under such conditions hybrid combinations have a greater chance of survival. Since for the most part the frequency of established hybrids will be low relative to the frequencies of the parental species, subsequent generations will consist of a series of recurrent backcrosses of the hybrids to one or other of the parents. The net effect will be a restricted transfer of various gene combinations from one species to the other—a process termed by the author "introgression." This will manifest itself as an increased variability of the recurrent parent species. Moreover, the variation will be unidirectional and not at random, i.e., it will consist of a complex of associated deviations, held together by linkage, and having the characteristics in a modified degree of the donor parent species from which it was derived. It should be possible, therefore, to develop objective techniques of measurement to assess the amount of introgression which has taken place. In favorable material it may even be possible to deduce the probable characters of the unknown donor species from a careful study of such deviations in the recurrent species.

After reading the book, one is left with at least a suspicion that the barrier between species may not be as "near-absolute" as is commonly considered to be the case, but one is not convinced that linkage per se is the basic mechanism for reducing recombination between them. Certain theoretical examples presented as a demonstration of the importance of linkage do not appear to be valid, or, at least, the data can be interpreted differently.

In spite of such controversial issues or perhaps because of them, the book holds the reader's interest from cover to cover. The ingenious techniques of measurement developed from a basically simple scatter diagram excite admiration and offer a widely adaptable method of recording otherwise subjective taxonomic observations in an objective and precise manner with a view to interpreting them genetically. It suggests a method of attacking problems of speciation in which the possibilities of cytological and genetic analysis are seriously limited by the material, and in which conventional taxonomic analyses are necessarily empirical.

S. G. Stephens

GENETICS AND CYTOLOGY

Introduzione allo Studio della Genetica per Medici, Agrari e Naturalisti.

By Carlo Jucci. Ulrico Hoepli, Milan. L.900.—(paper). xxiv + 420 pp. + 11 plates; text ill. 1944.

The author's opening remark is that a more correct title for this book could be "An Introduction to General Biology from the Standpoint of Genetics." It is, in fact, a book in which a wealth of factual information is marshalled so originally to illustrate general principles that it makes most delightful and interesting reading. Perhaps it may not be an advisable textbook for students, but it is certainly an excellent one for teachers. Among its many valuable features, I mention the following few:

Biochemical genetics is dealt with in one chapter, summarizing as an example the author's own work in the genetics of carotenoid and flavone pigments in the silkworm. There is not one relevant aspect of present biochemical genetics which cannot be illustrated clearly by this work. In particular, it brings out the importance of the genetic control of permeabilities, which is so conspicuously forgotten in most of the recent developments in this field. Gene control of morphogenesis is dealt with extensively (120 pp.) in both plants and animals: these six chapters are perhaps the best available review of this subject. About one-third of the book deals with the genetics of parasitic and symbiotic relationships, and here again the broad and happy choice of examples makes it a most valuable summary.

This book will be a very useful reference for teachers of genetics who wish to keep certain relations of genetics to general biology in the right perspective.

G. Pontecorvo

GENERAL AND SYSTEMATIC BOTANY

Journal of Experimental Botany. *An Official Organ of the Society for Experimental Biology. Volume I, Number 1.*

Edited by T. A. Bennet-Clark. Editorial Committee: E. Ashby, G. E. Blackman, R. Brown, F. G. Gregory, W. O. James, W. H. Pearsall, R. D. Preston, and M. Thomas. Published by Geoffrey Cumberlege, Oxford University Press, London. Subscription price 35s. per volume. Single numbers 14s. net. Three numbers per volume annually. No. 1: 131 pp. + 5 plates; text ill. March 1950.

According to the editorial policy, this new journal is "a medium for the publication of papers in the field of plant physiology, biochemistry, biophysics, experimental agronomy and related topics." The format and style are those characteristic of the Clarendon Press. The contents of the first issue are as follows:

two articles by Gregory, Milthorpe, Pearse, and Spencer on Experimental Studies of the Factors Controlling Transpiration; two Studies in Stomatal Behavior, one by Heath, and the other by Williams; The Path of Carbon in Photosynthesis, by Benson and Calvin; Demonstration of Compound Cilia in a Fern Spermatozoid by Means of the Ultra-violet Microscope, by Manton; Acid Metabolism of *Aspergillus niger*, by Allsopp; and The Effects of Sugar and Potassium on Extension Growth in the Root, by Brown and Sutcliffe.

GENERAL AND SYSTEMATIC ZOOLOGY

Procedure in Taxonomy. *Including a reprint in translation of the Règles Internationales de la Nomenclature Zoölogique (International Code of Zoölogical Nomenclature) with titles of and notes on the Opinions rendered to the present date (1907 to 1947). Completely indexed. Revised Edition.*

By Edward T. Schenk and John H. McMasters; revised edition enlarged and in part rewritten by A. Myra Keen and Siemon William Muller. Stanford University Press, Stanford, Cal.; Geoffrey Cumberlege, Oxford University Press, London. $2.50. viii + 93 pp. 1948.

This small work comprises directions for the preparation of manuscript for papers on systematic zoology; an introduction to the rules of nomenclature, and a republication of the rules. Being concerned primarily with details of manuscript form and of nomenclature, its title appears to be seriously misleading. That nomenclature is a part of taxonomy is clearly stated (p. 2), but taxonomy is then said to be equivalent to systematics. Except for its footnotes, which list some distinguished examples of systematic works, the book is thereafter limited to a discussion of editorial procedure and to nomenclature rather than to the principles of classification, which seem to the reviewer essential to a discussion of "Procedure in Taxonomy." It is perhaps not invidious to point out that the title of a work on editorial practice should be short, and that subtitles in scientific works (which require the writing of bibliographic references) should be composed so as not to require punctuation, or else should be punctuated. The trivia of nomenclature and of form of manuscript are discussed without humor or insight. It is one of the curses of taxonomy that complete nonsense, placed in correct form, may become part of its literature.

By means of the instructions in this book a young zoologist might draw up the description of a new species of animal for publication, or might present the reclassification of an old one in acceptable form. The systematic categories, the nomenclature of types, the storage of type specimens, the distinction between specific and trivial names, and Latin terms and abbreviations are discussed in 31 pages. There are 37 pages for the International Rules of Zoological Nomenclature, and 22 pages of index.

Even in a work whose scope is so specifically limited, it should have been pointed out that the taxonomic procedures described are the rules for playing a game. The game is, indeed, a distinguished one, engaged in by a world-wide group of players, and the rules are elaborate, international, and often obscure. Inadequate and premature descriptions of new species, prepared precisely according to the rules, or resurrections of long defunct names (also according to rule) rushed to the press in order to "win," do not constitute a contribution to systematics but are part of a game.

Descriptive zoology and botany are under fire in university circles throughout the world, perhaps mainly because we systematists have ourselves failed to distinguish the game from science, or bad work from good. There seems at last to be a revolt of major proportions against certain hitherto accepted operations under the nomenclatural rules, with which some members of the International Commission itself are in sympathy. What is at issue is the establishment of an Official List of generic and trivial names not subject to change, in a renewed effort to achieve a stabilization of nomenclature. That such stabilization has not been achieved, even for common species, during nearly 50 years of operation of the International Rules, is a major disgrace to systematic zoology, and reflects the fact that naming and name-changing have been so fascinating a game that even very eminent zoologists have pursued it to the detriment of zoology.

Karl P. Schmidt

ANIMAL MORPHOLOGY

The ABC's of Anatomy: *The anatomy of the human body simplified.*

By Elmer J. Tomasch. William-Frederick Press, New York. $3.50. iv + 24 pp. + 100 plates. 1947.

This little book is an attempt to present the human body anatomically to the artist. Semi-schematic drawings of the skeleton, in whole and in part, comprise the first portion of the book. Those muscles important to an appreciation of surface anatomy are shown in the next part, in textbook fashion and schematically arranged on the skeleton. The last portion stresses the main masses and rhythms of the human body. The anatomy is in large part adequately illustrated, and it is presented in a helpful and ingenious manner. It is unfortunate that the author has completely ignored the female, and that as an ideal body, he has chosen the unesthetic exaggerations of the weightlifting "muscle man." The book also suffers from being over-priced.

James M. Sprague

◆

Concise Anatomy.

By Linden F. Edwards. Blakiston Co., Philadelphia and Toronto. $5.00. xxiv + 548 pp. + 2 plates; text ill. 1947.

This is another textbook to add to the many which attempt to present the anatomy of the human body for the use of students in physical therapy, occupational therapy, medical technology, nursing, dental hygiene, physical education, etc. The actual descriptive part of the book, which comprises about two-thirds of the text, is an accurate, "boiled-down" version of a standard medical textbook of gross anatomy. Almost all of the many illustrations have been taken from standard textbooks. The first one-third of the book consists of a general introduction to embryology, histology, and neurology. The material is well organized, and the data are frequently grouped in tables helpful to the beginning reader. Throughout there is an appreciation of function. The bibliography consists almost entirely of textbooks, but they are well chosen. Even so, the omission of citations of the research literature removes the atmosphere of movement and of change in this part of the world of science, and the result is a static picture.

James M. Sprague

◆

Synopsis of general anatomy.

By Linden F. Edwards. Blakiston Co., Philadelphia and Toronto. $2.75 (paper). xvi + 151 pp. + 1 plate; text ill. 1948.

The ultimate stage in "boiling down." This ought to be very helpful to any student eager to absorb the minimum knowledge of the subject necessary to pass the final examination, or to one who cannot otherwise see the forest because there are too many trees. The *Synopsis* is well organized and competently prepared.

◆

Illustrations of Regional Anatomy. *I. Central Nervous System. II. Head and Neck. III. Abdomen. IV. Pelvis. V. Thorax. VI. Upper Limb. VII. Lower Limb. Seventh Edition.*

By E. B. Jamieson. Williams & Wilkins Co., Baltimore. Complete set, $20.00 (paper); (I) $3.50; (II) $4.00; (III) $3.00; (IV) $2.50; (V) $2.50; (VI) $3.00; (VII) $3.50. (I) iv + 51 plates + 2 pp.; (II) iv + 64 plates + 4 pp.; (III) iv + 44 plates + 2 pp.; (IV) iv + 35 plates + 2 pp.; (V) iv + 32 plates + 2 pp.; (VI) iv + 42 plates + 2 pp.; (VII) iv + 52 plates + 2 pp. 1947.

This loose-leaf atlas consists of 7 parts, comprising 51 plates of the central nervous system, 54 of the head and neck, 44 of the abdomen, 35 of the pelvis, 32 of the thorax, 42 of the upper limb, and 52 of the lower limb. The first edition, which appeared in 1934, consisted of the first five sections and 297 plates. The present edition is similar to the sixth, and has 320 plates, almost all of which are in color. Anatomical terms labeling the figures are in English. The figures, although not uniformly successful, are generally satisfactory, and are designed with an extensive use of sharp colors, to facilitate a rapid visualization of relationships and parts. The convenience of having the 7 parts bound separately and in loose-leaf form is considerable.

James M. Sprague

◆

The Head, Neck, and Trunk. *Muscles and Motor Points.*

By Daniel P. Quiring. Lea & Febiger, Philadelphia. $2.75. 115 pp. + 1 plate; text ill. 1947.

The present book is a companion volume to *The Extremities* by the same author, and is presented in similar manner. There is no text as such, but a brief description of the origin, insertion, function, innervation, and blood supply of the muscles accompanies each schematic drawing. The drawings are simple but clear, and the muscles are shown relative to the pertinent skeletal structures. The author gives the appropriate page references in Gray's and Cunningham's anatomies, where the student may find the original, detailed descriptions and more complete illustrations.

James M. Sprague

◆

Applied Anatomy of the Head and Neck *For Students and Practitioners of Dentistry. Second Edition.*

By Harry H. Shapiro. J. B. Lippincott Co., Philadelphia, London and Montreal. $10.00. xvi + 303 pp.; ill. 1947.

The second edition of this very useful textbook has been extensively revised, as may be seen by comparing it with the first (cf. *Q.R.B.*, 19: 62, 1944), which had 189 pages and 173 figures, none in color. The new edition has 14 chapters (compared to 9 in the first); and there is a new presentation of the (1) teeth and dental arches, (2) nose and paranasal sinuses, (3) reoentgenograms and anatomical landmarks, (4) glands of the head and neck, and (5) anatomy of oral infections. The chapter on development has been enlarged. The author shows an extensive knowledge of the research literature, listing 389 references in the bibliography. Although this excellent work is designed primarily for the use of students of dentistry, the student of medicine will find it a most useful correlative reference book.

James M. Sprague

* * *

Surface and Radiological Anatomy *for Students and General Practitioners. Second Edition Rewritten.*

By A. B. Appleton, W. J. Hamilton, and Ivan C. C. Tchaperoff. Williams & Wilkins Co., Baltimore. $7.00. viii + 332 pp.; ill. 1946.

This is an extensively rewritten second edition of the volume which appeared earlier (cf. *Q.R.B.*, 14: 95, 1939) under the authorship of Appleton, Hamilton, and Tchaperoff. The present work is extensively illustrated by 390 figures (51 in color), of which 190 are radiographs. There is an introductory chapter on general anatomy and methods, and separate and detailed consideration is given to the upper limb, the chest and back, the abdomen, the head and neck, the vertebral column, and the lower limb. This scholarly work can scarcely be commended too highly as a background of physical diagnosis for both student and practitioner.

James M. Sprague

* * *

ANIMAL PHYSIOLOGY

Le Sang. *"Que Sais-je?" Le Point des Connaissances Actuelles.*

By Louis Van Den Berghe. Presses Universitaires de France, Paris. 30 fr. (paper). 128 pp.; ill. 1946.

This small, well-printed book on blood is published in a series intended for the general public rather than for specialists, physicians, or medical students. It is written clearly and simply and manages to convey much useful information in spite of its small size. There is a brief historical introduction followed by a chapter on the functions of blood, with a simple exposition of the transport of oxygen and carbon dioxide. The normal constituents of blood—both cellular and chemical—are then discussed. Next there is a chapter on the origin and development of the cellular elements, followed by one on their functions and fate. A few pages are given to comments on the pathological variations of these cellular elements. The blood groups and transfusions are more extensively presented, and brief mention is made of the Rh factor. The concluding chapter gives some insight into current methods of investigation available for problems relating to blood. The text is well illustrated with diagrams and drawings, and there are a few tables. Historical aspects are not overlooked. The author has made good use of comparative physiology in emphasizing certain points.

F. Chinard

* * *

Blood Clotting and Allied Problems. *Transactions of The Second Conference, January 24–25, 1949, New York.*

Edited by Joseph E. Flynn. Josiah Macy, Jr. Foundation, New York. $2.25 (paper). 231 pp.; ill. 1949.

This conference was attended by 19 participants, all actively investigating problems concerned with blood coagulation, and representing such varied fields of medicine as anatomy, pathology, physiology, and biochemistry, as well as clinical medicine. The report includes the text of 8 formal papers, as well as a full transcript of the discussions, which were extensive and informal. The papers of major importance included reports of a thromboplastin-inhibitor (Tocantins and Carrol; Overmann); the formation and structure of the fibrin-clot (Ferry); the effects of the surface (of containers) on blood coagulation (Barker and Margulies); factors which influence the rate of conversion of prothrombin to thrombin (Flynn and Standley); and current views regarding the function of the blood platelets (Quick). There is also an extensive discussion of methods of standardizing thromboplastin preparations, with special reference to determination of the prothrombin time.

Great advances have been made in our knowledge of blood coagulation during the past decade, but a great deal more remains to be done before a clear comprehension of the process can be attained. Many different substances are concerned, enzymes and proenzymes, initiators, accelerators, and inhibitors, and few of these have been adequately characterized chemically or even obtained in a relatively pure state. The nomenclature is confusing, since different names have been applied by various investigators to what are presumably identical substances. The experimental technic is tricky and difficult at best, since there are variable factors which are not adequately understood and are difficult to control, and apparently slight differences in the set-up of the experiments may yield divergent results in different laboratories. Under such circumstances it is inevitable that there should be sharp differences in interpretation, and these are brought out in the discussions freely and frankly, and sometimes vehemently.

The Transactions contain no concise or systematic discussion of the subject as a whole, and readers who do not have a fair preliminary knowledge will find the going heavy and perplexing. Those who are better oriented will find this a valuable source of information regarding the status of the subjects discussed, as at the date of the Conference. For such it is highly recommended.

PAUL W. CLOUGH

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BLOOD CLOTTING AND ALLIED PROBLEMS. *Transactions of The First Conference, February 16–17, 1948, New York.*

Edited by Joseph E. Flynn. Josiah Macy, Jr. Foundation, New York. $3.25 (paper). 179 pp.; ill. 1948.

This conference served as a model of the Second Conference, the Transactions of which are discussed above. The Transactions are opened by an excellent summary (by Jaques) of those facts concerning hemostasis and coagulation which are definitely or reasonably well established. He has not attempted a critical analysis of the present status of the more newly discovered factors which are under active investigation and concerning which there is much controversy—some of it acrimonious.

The formal papers include reports regarding fibrinolytic enzymes (Astrup); factors initiating and accelerating thrombosis (Brinkhous); "unsolved problems," concerned chiefly with the chemistry and physical make-up of the fibrin clot (Edsall); protein equilibrium reactions in the blood clotting mechanism (Seegars and Ware); and the value of prothrombin determinations (Wright, Bramble, Olwin, Quick, Smith, Luck, individually). A highly useful feature is the inclusion, in the appendix of the precise technic used in determining prothrombin in 8 different laboratories.

Although this work is now over 2 years old, those interested in this field will find it still a valuable source of pertinent information not easily accessible elsewhere.

PAUL W. CLOUGH

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STUDIES ON DIETARY AND OTHER FACTORS AFFECTING THE SERUM-CALCIUM LEVELS OF SHEEP. *Bull. No. 240, Parts I to VI, Coun. sci. ind. Res., Commonw. Austral.*

By M. C. Franklin, R. L. Reid, and I. L. Johnstone. Council for Scientific and Industrial Research, East Melbourne, Australia. Free upon request (paper). 77 pp. 1948.

ANIMAL NUTRITION

ADVANCES IN FOOD RESEARCH. *Volume I.*

Edited by E. M. Mrak and George F. Stewart. Academic Press, New York. $7.50. xvi + 459 pp.; ill. 1948.

In this volume twelve contributors have discussed the following subjects: the physiology and chemistry of rigor mortis, with special reference to the aging of beef; factors influencing the vitamin content of canned foods; the physiological basis of voluntary food intake (appetite); biochemical factors influencing the shelf life of dried whole eggs and means for their control; factors affecting the palatability of poultry, with emphasis on histological post-mortem changes; the deterioration of processed potatoes; the influence of climate and fertilizer practices upon the vitamin and mineral content of vegetables; non-enzymatic browning in fruit products; microbial inhibition by food preservatives; and high-polymer pectins and their de-esterification.

Investigators in food research have quickly applied to the problems of food technology all of the new discoveries in biochemistry and other biological sciences. Their publications are dispersed, and are often not available to those who could profit by reading them. The annual volume, in which experts prepare review articles, has become a necessity in a number of fields of science and technology. The present volume sets a high standard, and its usefulness is assured.

E. V. MCCOLLUM

BIOCHEMISTRY

ADVANCES IN PROTEIN CHEMISTRY. *Volume V.*

Edited by M. L. Anson and John T. Edsall. Associate Editor for the British Isles: Kenneth Bailey. Academic Press, New York. $7.50. ix + 481 pp. 1949.

The present volume of this valuable series begins with a discussion of methods of peptide synthesis in vitro, by Joseph S. Fruton, in 75 pages which include extensive tables of the optical rotation and melting points of known peptides. There follows a critical survey of methods of amino acid analysis of proteins, by G. R. Tristram. The formidable difficulties of this subject are attested by a vast literature. "Progress was delayed for many years because methods of analysis were, in the main, based upon the gravimetric principles of elementary analysis, and analysts only slowly realized the difficulties which attend the quantitative isolation of a single constituent or any of its derivatives from biological materials. In recent years the development of new methods, micro in scale, based upon many novel principles (e.g., isotope dilution, microbiological assay, partition chromatography) has revolutionized amino acid analysis," so that it is now reasonable to hope "that valuable information will be obtained upon the amino acid stoichiometry of proteins." However, the new methods are to some extent still in the developmental stage and are by no means without their special difficulties. Not the least of the difficulties still remaining are the means of establishing evidence of significant purity of the protein to be analyzed, and of avoiding loss or alteration of the residues during hydrolysis. However, "while there are still differences in the results of analysis the degree of agreement is remarkable and, for the first time in the history of amino acid analysis, it is possible to make use of amino acid data with justifiable confidence." Tristram then develops an interesting but necessarily highly tentative discussion of initial inferences regarding protein structure from the evidence of amino acid analysis. Much weight is given to the concept of separate peptide chains, from the evidence for terminal groups derived from the work of Sanger and others. If there are separate polypeptide chains, other evidence seems to require that they be united by covalent linkages, which might be disulfide bonds, but do not seem to be so in some cases at least. "... The stoichiometry of proteins follows no simple rule (such, for instance, as that propounded by Bergmann and Niemann)."

The biological evaluation of protein is discussed by J. B. Allison, in a review of nitrogen balance studies and protein effects upon growth and tissue regeneration. One of the most interesting points emerging from this rapidly growing field has been put as follows: "If it is true that essential amino acids are not stored individually in the tissues ..., and if, moreover, the synthesizing mechanisms which fabricate complete tissue proteins must have available all the necessary building stones ..., it would seem likely that the synthesizing mechanisms operate on a 'perfectionist' or 'all or none' principle to the extent that if they cannot build a complete protein when one is required they will build none at all. This would suggest also, that the process of synthesis must be total rather than partial, and to be effective the synthesizing mechanism must have available and practically simultaneously all the essential amino acids in adequate proportions and amounts.

There is a relatively short descriptive survey of milk proteins by T. L. McMeekin and B. D. Polis, followed by a broad discussion of plant proteins and protein metabolism in plants, by J. W. H. Lugg. Among the points brought out here is the fact that, with certain exceptions, the bulk proteins of plants appear to be of somewhat similar amino acid composition, in contrast to the bulk proteins of seeds which are of distinctly dissimilar composition. Plant proteins, like animal proteins, are being continually broken down and rebuilt. The important question, whether synthesis is the reverse of catabolism, or whether the processes constitute a cycle involving different routes, can perhaps be approached advantageously in plants.

There are articles on synthetic fibres made from proteins, by Harold P. Lundgren, and protein chemical aspects of tanning, by K. H. Gustavson. Finally, lest we become complacent, Albert Claude contributes a brief consideration of proteins, lipids, and nucleic acids in cell structures and functions. He says: "The most significant development in recent years has been the demonstration that important cell functions are segregated in mitochondria and homologous large granules." It has been shown that the cytochrome system which utilizes molecular oxygen is localized in these elements, probably exclusively. Also D-amino acid oxidase, the fatty acid oxidase system, and members of the Krebs cycle have been shown to be segregated in mitochondria. It seems possible that the energy derived from anaerobic glycolysis, on the other hand, is mediated through ribonucleic-acid-containing elements in the cytoplasm.

Evelyn Howard

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Les Lipides. *Paris, 5 au 12 Janvier 1948, XI. Colloques Internationaux du Centre National de la Recherche Scientifique.*

Centre National de la Recherche Scientifique, Paris. 1000 fr. (paper). 399 pp. + 3 plates; text ill. 1949.

This volume presents the proceedings of an international colloquium on lipids held in Paris in January 1948. The contents have already been published as the first four numbers of volume II of the *Archives des Sciences Physiologiques* (1948). The volume is divided into eight sections, each of which contains one or more general reviews followed by a more detailed presentation of recent experimental work. The section headings, which indicate the scope of the symposium, are: (1) digestion and intestinal absorption, (2) deposition and mobilization of reserve fats, (3) lipid transport in the blood; lipoprotein linkages in blood and tissues, (4) metabolism of the higher fatty acids, (5) desaturation of the higher fatty acids and of the essential fatty acids, (6) role of the lipids in blood coagulation, (7) phosphoaminolipids and their degradation products, and (8) the problem of the oxidation of fats and antioxidants.

Of the 26 communications by 24 scientists, 19 are in French and 7 in English. Though it is not possible to describe all of them, a few may be mentioned as particularly interesting. Macheboeuf has contributed an extensive review of his work on the lipoproteins of blood, this being followed by a review on cellular lipoproteins by Chargaff. Frazer, who elsewhere in this volume discusses his work on the digestion and absorption of fats, presents his work on artificial lipoproteins and reports some new observations on hemoglobin-detergent complexes. Barnes and Gurin review the formation and utilization of ketone bodies. Barnes also contributes one of the three papers on antioxidants. Though the material presented does not cover every facet of the field of lipids, this book should interest workers in lipid chemistry and lipid physiology.

F. Chinard

Partition Chromatography. *A Symposium Held at London School of Hygiene and Tropical Medicine on 30 October 1948. Biochemical Society Symposia No. 3.*

Organized and edited by R. T. Williams, assisted by R. L. M. Synge. Cambridge University Press, London and New York. $1.50 (paper). 103 pp. + 1 plate; text ill. 1950.

The introduction is followed by eight chapters, as follows: Some Theoretical Aspects of Partition Chromatography, by A. J. Martin; Application of Partition Chromatography to the Study of Protein Structure, by F. Sanger; Partition Chromatography and its Application to Carbohydrate Studies, by S. M. Partridge; Anthocyanins, Flavones and other Phenolic Compounds, by E. C. Bate-Smith; Partition Chromatography of Organic Acids, Purines and Pyrimidines, by R. S. Elsden; Partition Chromatography with Stationary Phase Other than Pure Water, by A. A. Levi; General Review of the Applicability of the Method, by R. L. M. Synge. There is a supplementary bibliography, which extends citations beyond the references given at the end of each chapter. This covers Review Articles; Technique; Amino-Acids, Peptides, Proteins and their Derivatives; Carbohydrates and Related Substances; and Other Substances. This series of articles by distinguished investigators in the field of this mightiest of all analytical tools of the chemist is a highly valuable contribution.

E. V. McCollum

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Fatty Acids Antibacterials from Plants. *Carnegie Institution of Washington Publication 586.*

By H. A. Spoehr, J. H. C. Smith, H. H. Strain, H. W. Milner, and G. J. Hardin. Carnegie Institution of Washington, Washington, D. C. 75 cents (cloth); 50 cents (paper). iv + 67 pp.; ill. 1949.

MICROBIOLOGY

Annual Review of Microbiology. *Volume III.*

Edited by Charles E. Clifton, Sidney Raffel, and H. Albert Barker. Annual Reviews, Stanford, Cal. $6.00. viii + 476 pp.; ill. 1949.

The third volume of this series is the best to date. Among the 18 reviews included, there is a remarkably high proportion of first-rate critical essays. Particularly noteworthy are: Bacterial Variation (J. Lederberg); The Morphology, Cytology, and Taxonomy of the Actinomycetes (D. Erikson); Ciliated Protozoa; Cytogenetics, Genetics and Evolution (T. M. Sonneborn); Types of Acquired Immunity against Infectious Disease (S. Raffel); and The Growth of Bacterial Cultures (J. Monod). Other topics discussed include: Metabolism of Microorganisms (W. W. Umbreit); Nutrition of Microorganisms (E. E. Snell); Constituents of Viruses (C. A. Knight); Action of Antibiotics *in vivo* (W. C. Cutting); The Cellular Basis of Immunity (W. H. Taliaferro); Virulence and Pathogenicity (D. W. Watson and C. A. Brandly); Chemistry of Toxins (L. Pillener and K. C. Robbins); Nature and Variability of Disease Resistance in Plants (H. Hart); Oral Microbiology (R. W. Harrison); Dermatotropic Viruses (G. J. Buddingh); Food Microbiology (H. O. Halvorson); Recent Development in Microbiological Techniques (L. S. McClung); and Bacteriophage (J. Fong).

R. Y. Stanier

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Inventaire et Description des Bacilles Paratuberculeux.

By Paul Hauduroy. Masson et Cie., Paris. 400 fr. (paper). iv + 168 pp. 1946.

Some 160 species and strains of Mycobacteria are herein described, the descriptions being given in alphabetical order of the names of the individuals who first reported them. Many very imperfectly characterized isolates are included. *Mycobacterium tuberculosis, M. paratuberculosis* (Johne's bacillus), and the various acid-fast organisms isolated from the lesions of leprosy have been excluded from the descriptions. Although many of the paratubercular organisms were isolated from human or animal pathological material, only a minority are pathogenic to laboratory animals. Other characteristics are discussed, particularly the source from which the bacilli were isolated (habitat). There is an interesting tabulation and discussion of cross reactions between various "paratuberculins" and true tuberculins in animals and in man.

The book should be of great value to specialists in the taxonomy and identification of Mycobacteria. It will be of considerable collateral interest to those working in the field of experimental tubercular infections.

Walter C. Tobie

HEALTH AND DISEASE

Rickettsial Diseases of Man. *A Symposium on the Rickettsial Diseases of Man, Organized by the Section on Medical Sciences of the A. A. A. S. and Presented at the Boston Meeting on December 26–28, 1946.*

Organized by Malcolm H. Soule; edited by Forest Ray Moulton. American Association for the Advancement of Science, Washington, D. C. $6.25 ($5.25 to AAAS members). iv + 247 pp.; ill. 1948.

This volume consists of 27 papers prepared by as many authors for a symposium organized by the Section on Medical Sciences of the AAAS and presented at the Boston Meeting on December 26–28, 1946. The series of papers, each concerned with a different phase of the subject, constitutes a comprehensive and thorough review of the rickettsial diseases. The authors are recognized authorities, many of them being investigators who have spent years studying the subjects upon which they write.

Investigators during World War II contributed greatly to our knowledge in regard both to the nature of rickettsiae and the methods of control of the infections. Those advances are particularly stressed in the present volume. The discussions range from certain basic aspects of the study of rickettsiae, such as are contained in the papers on their general biologic character and their classification, through descriptions of the clinical aspects of the various diseases, their pathology, treatment, epidemiology, arthropod vectors, and reservoirs of infection. Also included are descriptions of the various methods of laboratory diagnosis, preparation of vaccines, and control of vectors.

Most of the papers are well illustrated with maps, graphs, patient's charts, or tabulated matter as is appropriate. References are given at the end of each paper. As with many volumes of this kind, i.e., those composed of chapters by a number of contributors, no index is included. Although perhaps understandable, the omission is regrettable, because the book will find its greatest value as an authoritative reference work. Nevertheless, it serves admirably to mark the progress of knowledge in the field of rickettsial diseases, and will long remain a highly valuable source of information.

Francis B. Gordon

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Coccidiosis. *Ann. N. Y. Acad. Sci., Volume 52, Article 4.*

Edited by Sterling Brackett; by 44 authors. The New York Academy of Sciences, New York. $3.00 (paper). Pp. 429–624 + 1 plate; text ill. 1949.

This publication consists of papers presented at a conference held at the New York Academy of Sciences, March 4–5, 1949, under the chairmanship of Sterling Brackett. Limitations of space prevent a complete description of all the 28 pages. A critical evaluation of the quality of the contributions may be left to specialists. Nevertheless, the publication is an important one on account of the tremendous economic losses caused by coccidial infections in livestock. The compilation will probably exert a useful influence for many years to come.

Walter C. Tobie

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La Médecine Infantile. *Collection Armand Colin (Section de Biologie), Number 234.*

By Robert Broca. Librairie Armand Colin, Paris. 100 fr. (paper). 188 pp.; ill. 1943.

This pocket-size volume covers infectious diseases, endocrinology, nutrition, and congenital diseases from a pediatric point of view. One chapter is devoted to acrodynia. As of the time of publication, it seems well up to date. Authors and dates are mentioned freely in the text, but references are lacking except for a list of 40 books. Those interested in French clinical views may find the book of some incidental significance. To the average American biologist (if indeed there is such an individual) it offers little of value.

Walter C. Tobie

PSYCHOLOGY AND ANIMAL BEHAVIOR

Introduction to Methods in Experimental Psychology. *The Century Psychology Series. Second Edition.*

By Miles A. Tinker. D. Appleton-Century Co., New York and London. $4.00 (paper). viii +232 pp. + 2 plates; text ill. 1947.

"About 30 per cent of the material in the revision is new or different from that in the original edition. The major changes are as follows: chapters on the Estimation of Temporal Intervals, Self-Rating of Personal Traits, and The Adjustment Inventory has been dropped. New chapters on Clerical Aptitude, Social Attitudes, and Measurement of Introversion-Extroversion have been added. There has been thorough revision of sections on variability, art aptitude, and, in part, correlation...."

◆

Psychological Warfare.

By Paul M. A. Linebarger. Infantry Journal Press, Washington, D. C. $3.50. xvi + 259 pp.; ill. 1948.

The author has compiled what he modestly calls a "patchwork of enthusiastic recollection" of his experience of five years as "civilian expert and as an army officer in American psychological warfare facilities—at every level." His work is based on experience rather than research, on practice rather than on theory. He treats his subject in an informal, pithy, and newspaperish style. The result, however, is considerably more than a "patchwork," for sooner or later he discusses all critical phases of psychological warfare from the practical propagandist's point of view. Linebarger's survey is divided into three principal sections: Definition and History; Analysis, Intelligence, and Estimate of the Situation; and Planning and Operations. This book is practically the only available general source of information concerning the whole program of psychological warfare conducted during World War II, and for this reason it will be read by many who are curious as to the successes and failures of psychological warfare as an adjunct to military operations. The publication of this book is a small but significant reaffirmation of the importance of ideas over weapons in ideological struggles, a salutary reminder in a period when political offense and defense in the competition of ideas have come, almost pathologically, to depend upon armed violence.

JOSEPH C. FRANKLIN

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THE STORY OF HYPNOTISM.

By Robert W. Marks. Prentice-Hall, New York. $3.00. xii + 246 pp. 1947.

This is a popularized but very complete and accurate report on hypnosis, its recognition as a psychic phenomenon, and its development as a social phenomenon. The author first orients the reader on the subject by defining hypnosis, mostly through description of the induction stages. He then takes up Mesmer and the succession of physicians after him who used hypnosis in one form or another. He presents faith cures as a form of suggestion. Without being dogmatic or belligerent, he ascribes spiritualism, religious mysticism, and ecstasy to forms of hypnosis. The final chapter is devoted to hypnosis as a factor, through mass suggestion, in our present social structure—Goebbel's propaganda, for example, acting as an hypnotic influence on the minds of the German people. Marks has made no attempt to sensationalize his subject, although it is a topic which lends itself to such exploitation. His restraint and good taste are commendable.

HELEN ARTHUR

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PROBLEMS OF EARLY INFANCY. *Transactions of the Second Conference, March 1–2, 1948, New York. With Supplement Covering Special Meeting, July 18–19, 1947, New York.*

Edited by Milton J. E. Senn. Josiah Macy, Jr. Foundation, New York. $1.00 (paper). 120 pp.; ill. [No date.]

PROBLEMS OF INFANCY AND CHILDHOOD. *Transactions of The Third Conference, March 7–8, 1949, New York.*

Edited by Milton J. E. Senn. Josiah Macy, Jr. Foundation, New York. $1.25. 156 pp. 1949.

These publications are reports of two conferences sponsored by the Josiah Macy, Jr. Foundation. The conferences are part of the Foundation's program for furthering scientific knowledge by having workers in different areas of a given field meet to exchange ideas and points of view. In this instance the topic of infancy and early childhood involved the efforts of 25 well-known pediatricians, psychiatrists, obstetricians, and psychologists. These people met for two days in 1948 and 1949, and the papers presented, with the attendant discussion, are faithfully reproduced here. The effect is almost like being actually present in the serious but informal business of working through to some general understanding of concepts that affect these several disciplines.

In 1948 the main concern was the effect on the infant of factors in pregnancy. Helen Deutsch discussed psychological problems of pregnancy. John Parks, Howard Walser, and Albert Vollmer reported from the obstetrician's point of view on the emotional factors in pregnancy, and how the relaxation method of childbirth affects the mother and baby. A supplement, added to the 1948 Transactions, reports a special meeting held in July 1947. In this a number of foreign physicians gave reports on what had happened in their countries to children in wartime and how those experiences are affecting their mental health today. These are quite moving, if rather simple, statements from Holland, France, Sweden, and Switzerland.

In 1949 only two prepared papers were given: one by Sibylle Escalona on The Psychological Situation of Mother and Child upon Return from the Hospital; the other, by Lucie Jessner and Samuel Kaplan, an Observation on the Emotional Reactions of Children to Tonsillectomy and Adenoidectomy. Both are important and provocative issues and caused a great deal of discussion. It is to be hoped that such an exchange of ideas does have the desired effect of strengthening the unity and the understanding of all the medical personnel who deal with expectant mothers, infants, and young children.

HELEN ARTHUR

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THE RESPONSIVENESS OF KINDERGARTEN CHILDREN TO THE BEHAVIOR OF THEIR FELLOWS. *Monographs of the Society for Research in Child Development. Volume XI, Serial Number 43, Number 2, 1946.*

By Esther Kite Harris. Society for Research in Child Development, National Research Council, Washington, D. C. $2.50 (paper). viii + 184 pp.; ill. 1948.

This is another psychological monograph turned out with typical, if monotonous, competence. It follows the standard form, so there are no surprises in the presentation or in the conclusions summed up so efficiently in the last pages.

Using a pictorial Guess Who technique on 24 kindergarten children, plus their teacher's evaluations and parents' reports, Mrs. Harris is able to state that social responsiveness is a personality factor which is not related to age, I.Q., or sex. Even in kindergarten children, there is a wide range of social responsiveness—some preferring a small group of congenial friends and others a larger social orbit. The children gave evidence that their judgments on each other were largely determined by their own social indoctrination, whence follows the inevitable hint that children should be "rightfully guided and directed" so that their inherent social responsiveness will be harnessed to the best interests.

HELEN ARTHUR

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KINDER UND JUGENDLICHE ALS ZEUGEN. *Psychologische Praxis: Schriftenreihe für Erziehung und Jugendpflege, Number 3.*

By Ernst Probst. S. Karger, Basel and New York. S. fr. 3.80 (paper). 55 pp.; ill. 1945.

This booklet, like the 4 others whose reviews follow, is a part of the Swiss series, Psychological Practice. These publications have been written for teachers, for educators, and for psychological therapists in the fields of child guidance, adolescent counseling, etc. Their purpose is "to guide and interpret the factors and forces encountered in actual practice but not to give theoretical explanations."

The editor of the entire series is the author of this publication. Its theme is the question: are the testimonies of children and juveniles as trustworthy as those of adults, or are their observations and statements to be doubted, either generally or in special cases? The author's conclusions are based on 30 cases in which he, as a school psychologist in Basel, acted as court-advisor. The conclusions may be summarized as follows:

(1) The judge should not base his decision on testimonies of children under 4 years of age. Reasons: the egocentric attitude, the lack of self-criticism, and the insufficient development of language prevailing in this age group.

(2) Between the ages of four and seven the following factors are likely to influence trustworthiness negatively: heightened suggestibility, strong feelings of sympathy or antipathy, tendency to exaggerate and confabulate. The advice given is to have those children questioned as soon as possible by experts in child psychology.

(3) In the group from seven to the beginning of puberty (eleven to thirteen) adverse influences are: the need for self-assertion, the desire to play a role, the desire to arouse attention. Incidents actually observed are fused with expectations and rumors. Day dreams, lack of self-criticism, and a tendency to dramatize call for special scepticism whenever sexual accusations are involved.

(4) The period of puberty may add to these factors a particular sense of justice: to betray a secrecy shared with one's companions is considered the worst crime. Yet even a friend suspected by others of some delinquent act is immediately condemned: the child's own inner insecurity and need for self-protection lead to public separation from the friend in self-righteous indignation.

(5) Simple, direct observation cannot find signs that mark the unreliable witness. A psychologist needs the expert interpretation of tests to evaluate intellectual development, memory, and affective behavior. The author worked with the Binet test; with the exposition of pictures for a few minutes, followed by 12 correct and 12 false (suggestive) questions; or with a similar procedure in recounting a brief story read. These tests were given to control groups in the classroom. Finally, he made use of the Rorschach test.

(6) Three protocols are given in some detail to demonstrate how a tendency to pathological living may reveal itself in one or another of these tests. The author, however, emphasizes the possibility that such a tendency may not always manifest itself in such tests as he carried out. The more tests are used and the more varied they are, the greater will be the chance to develop methods by which the general reliability of a witness can be recognized and graded.

WALTER O. JAHRREISS

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PSYCHOLOGIE DER BERUFSBERATUNG. *Psychologische Praxis: Schriftenreihe für Erziehung und Jugendpflege, Number 4.*

By Richard Meili. S. Karger, Basel and New York. S. fr. 4.35 (paper). 64 pp. 1948.

This publication grew out of its author's great experience as a vocational psychologist and counselor. It is well written and reveals mature judgment and sincere concern. "Nobody," the author writes, "can be more keenly aware of the forces of our economic and social conditions than the vocational counselor; he has to take them into account and adjust to them lest he give futile advice. Yet, his real task remains to aid and assist the individual against the all-powerful machinery of modern society." The author makes intensive use of psychological tests and defends them against undeserved criticism. The fault usually lies, he thinks, with those psychologists who have neither the necessary experience to give a test carefully nor to interpret it, and not with the tests or their methods. "The essential traits and aptitudes of an individual manifest themselves in the most different situations and will not escape the scrutiny of exact tests and observations."

WALTER O. JAHRREISS

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ENTWURZELTE UND DISHARMONISCHE KINDER. *Psychologische Praxis: Schriftenreihe für Erziehung und Jugendpflege, Number 5.*

By Karl Heymann. S. Karger, Basel and New York. S. fr. 4.35 (paper). 56 pp. 1946.

The American reader will find in this pook a distinctly European flavor. The dynamics of the disharmonic, the neglected, the uprooted and asocial juvenile behavior seem unduly simplified; nor will statements like the following be easily accepted: "In an individual with a certain hereditary disposition to abnormal physical reactions . . . an illness may manifest itself and its conditions may lead directly to stealing, just as directly as a sore throat to coughing"; some formulations may sound too metaphysical, even "existential." It may be strange to hear that there are certain professions for which the absence of strong and constitutional abilities is a necessary precondition, e.g., the educational therapist. His specific aptitudes at any rate are never given in the make-up of his personality but have to be acquired in personal crises, during which they emerge "new and quasi for the first time." His profession is founded on "suffered" abilities and talents.

Yet it seems to me that these and many more of the author's formulations will appear more acceptable if one can translate them into one's own familiar terminology. The chapters on disharmonic children and on "body-feeling," i.e., the inner experience of one's own somatic existence and functioning, show the author's unorthodox approach to old problems. If an individual is seized consciously by rhythms, as in dancing, then his "body-feeling" becomes vague and weak. In contrast, a state of being unconsciously imbedded in rhythms brings about a feeling of well-being; it increases the inner somatic experience so that the body is felt as a closed entity. This sensation also automatically closes down the bladder—so to speak—into the deepest sleep. In children, who are seized by, or given to, consciously felt rhythms the "body-feeling" is so feeble that the bladder cannot be closed during sleep. At least, the author considers this mechanism as one possible cause of enuresis, among many. He attributes to color-blindness an important role as a dynamic factor in disharmonic children and gives interesting contributions to the knowledge of personality disturbance as a reaction to the impairment of a sensory organ.

A last chapter on the Psychology of the Study of Human Behavior (Seelen-Beobachtung) deals with the task of perceiving and understanding "man" the individual. The author criticizes Kretschmer's typological approach, because it does not permit one to grasp the totality of "man's being" in the individual. Yet, if this never-to-be-finished task belongs somewhere, surely it belongs to philosophy, and not to psychology or any other science.

Walter O. Jahrreiss

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Das Kind und seine früheste Umwelt. *Psychologische Praxis: Schriftenreihe für Erziehung und Jugendpflege, Number 6.*

By Fritz Stirnimann. S. Karger, Basel and New York. S. fr. 6.—(paper). 72 pp. 1947.

This publication gives a very detailed description of the child's development step by step from birth till the end of the first year. It is written by a pediatrician whose interest in the psychology of child development is evident and attested to by an index of his own publications. It is—by the way—the only one of the volumes of this series to be reviewed in this issue which helps the reader by including a brief bibliography and index. The general theoretical orientation follows von Monakow's biological teachings and von Uexkuell's formulation of the individual's specific sector of total environment, his "Umwelt" to which he adjusts himself and which in turn he influences.

Walter O. Jahrreiss

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Kritische Phasen der Kindheit. *Psychologische Praxis: Schriftenreihe für Erziehung und Jugendpflege, Number 8.*

By Karl Heymann. S. Karger, Basel and New York. S. fr. 4.80 (paper). 52 pp. 1949.

Seven chapters, loosely joined together, are filled with observations and aphoristic statements: some critical, some original, and most of them stimulating. In the child's development crises are normal occurrences, and they are necessary for the growth of the personality. Critical periods are the times of transition from one developmental stage to the next, and regression to the behavior of a preceding phase is the common mode of reactions to existing conflicts. But antegression also occurs, as in the "precocious" child. Dreams of losing something precious are frequent in periods of transition: the years of early childhood seem paradise, but a paradise lost and not to be regained. During prepuberty and puberty, regression to "role" playing is not uncommon; yet the role is now built into an actual situation, into the frame of everyday reality. The playing, therefore, is apt to be misunderstood and taken for some kind of surprising misbehavior.

In a chapter on Drawings in Childhood, the author stresses the fact that the small child (two to six) is living in his own world, taking it for granted; yet he longs to understand the world of the grown-ups and to take part in their "reality." The child gropes for new ways of expression, like drawing and painting, in order to break the threatening isolation. It is an attempt at self-healing, and it should be used diagnostically and therapeutically.

Chapters on the school system as organism, on testing for occupational aptitudes, and on occupation and personality contain good suggestions and observations. The author describes a characteristic crisis of the European "apprentice." It is said to occur usually during the second year of apprenticeship and is interpreted as the individual expression of the conflict between personal interest in work and workmanship and the demands of the machine to deny all personal interests.

Walter O. Jahrreiss

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The Gifted Child Grows Up. *Twenty-Five Years' Follow-Up of a Superior Group. Genetic Studies of Genius, Volume IV.*

By Lewis M. Terman and Melita H. Oden, in association with Nancy Bayley, Helen Marshall, Quinn McNemar, Ellen B. Sullivan. Stanford University Press, Stanford; Geoffrey Cumberlege, Oxford University Press, London. $6.00. xiv + 448 pp. 1947.

A follow-up study by Terman of his original California group of gifted children in 1940 and 1945 has resulted in this the fourth volume in the now famous *Genetic Studies of Genius*. With this report we are brought up to date regarding the lives and achievements of more than a thousand people of superior intelligence who were selected as children by Terman 25 years ago for a comprehensive lifetime study. We find them now as adults about 35 years old, taking their places in their home communities, and with their adult careers well under way. The most general significant finding of the report is the group's continued superiority to the general population in virtually all phases of life activity.

The book has been well organized by the authors, who have also expertly summarized a prodigious quantity of data neatly and with objectivity. Interpretation has been held to a minimum, the authors preferring to have the facts, of which they provide a storehouse, speak for themselves.

This gigantic undertaking—a methodical, longitudinal study of genius—is now in its half-way period, plans having been made to continue it for another 25 years. It is remarkable to realize that almost all we reliably know and understand regarding children of superior intellectual endowment is directly or indirectly the result of Terman's pioneer work, of which this book is another *in progress* report. Terman has provided the background necessary for the development and implementation of the education and guidance of children of superior intelligence so as to prepare them better to shoulder the disproportionate responsibilities that fall on them—the responsibilities of self-fulfillment and community leadership.

Joseph C. Franklin

* * *

The Psychoanalytic Study of the Child. *Volume III/IV.*

Edited by Phyllis Greenacre, Heinz Hartmann, Edith B. Jackson, Ernst Kris, Lawrence S. Kubie, Bertram D. Lewin, Marian C. Putnam, Rudolph M. Loewenstein, Anna Freud Willie Hoffer and Edward Glover. International Universities Press, New York. $10.00. 493 pp.; ill. 1949.

This volume continues the series begun several years ago in which current papers that deal with psychoanalytic concepts related to children and their development are brought together. As in the preceding volumes (*Q.R.B.*, 23: 91, 1948), the papers are excellent, informative, and stimulating.

The collection covers a wide range, the papers being grouped under several headings. The first part is devoted to theoretical considerations. There are 3 papers on the development of aggression in this section. One, by Anna Freud, and entitled Aggression in Relation to Emotional Development; Normal and Pathological, is particularly interesting.

In the second section of the book are grouped the papers falling under Clinical Problems. This is by far the most dramatic part of the volume. Here many of the really first rate child analysts have given reports of their cases. To any reader oriented in the field of psychoanalysis, these are engrossing. Berta Bornstein reports in unusual detail The Analysis of a Phobic Child—Some Problems of Theory and Technique in Child Analysis. It covers the high points of a 3-year analysis of a 5½ year old boy with a severe school phobia. The child is a remarkable case and serves to illustrate the author's observations of the theoretical and technical implications involved. Editha Sterba, in her paper Analysis of Psychogenic Constipation in a Two-Year Old, is equally fascinating. Elisabeth R. Geleerd, Bruno Bettelheim, and Melita Sperling and others have also contributed papers to this section.

Part III is on psychoanalytic guidance work. Part IV is devoted to Problems of Group Psychology. Part V is a survey of the literature on psychogenic feeding problems; and Part VI is an historical report by Bertram D. Lewin on Child Psychiatry in the 1830's.

Once again, the reviewer is impressed by the continuity of thought and even of style which prevails throughout this yearbook. It is apparent that though the authors are widely separated geographically, they are intellectually united. This does not mean to imply sameness or repetitiousness. The authors are strong individuals, with new ideas to present, but they are working within the framework of traditional Freudian thought and that is the unifying factor.

Helen Arthur

HUMAN BIOLOGY

Society, Culture, and Personality: Their Structure and Dynamics. *A System of General Sociology. Harper's Social Science Series.*

By Pitirim A. Sorokin. Harper & Bros., New York and London. $5.00. xiv + 742 pp. 1947.

In this patently monumental work, Sorokin "attempts to present a system of sociology as a generalizing science of sociocultural phenomena possessing its own set of referential principles, its own meaningful-causal method ... Little concerned with physical, biological, and other 'presociological' problems," he has confined himself to a study of "sociocultural phenomena in their structural and dynamic aspects." The author's method is scholarly, empirical, and rational and, while drawing on the experimental data of science, is frankly tentative, for he reminds us that in this area attempts at "absolute exactness" result "ordinarily in misleading preciseness acquired at the expense of approximate validity."

Sorokin's systemization of sociocultural phenomena is based on the interaction of two or more persons involving (a) society (organizations and groups of individuals), (b) culture (including goals, values, communications, norms, etc. and the agencies which "express and objectify" them), and (c) the personalities of the members "which are molded in their psycho-social, and also in part their biological, properties by the culture in which they are raised."

According to Sorokin, these components are inseparable and indivisible in his superorganic world. This interaction of the three basic items is lengthily and closely argued in a style considerably difficult to read. Those who are motivated to bring the social chaos and crises of our times into manageable dimensions in their thinking will find Sorokin's orientation provocative and rewarding.

Joseph C. Franklin

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